JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CLII, No. 6. 76TH YEAR. DECEMBER, 1901

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ELECTRICAL SECTION.

Stated Meeting, held Wednesday, June 19, 1901.

MINTING MACHINERY AND APPLIANCES

BY EDWIN S. CHURCH.
Superintendent of Machinery U. S. Mint, Philadelphia.

The electrical equipment of the new United States Mint is comparatively simple, similar devices being found in many modern shops, so therefore I will present to the Electrical Section of the Franklin Institute a general outline only of the mechanical operations involved in the coinage of money, together with a brief description of the various installations.

The equipment will include several new features, which as yet are in an experimental stage, and will not be alluded to in this paper.

The development of coining machinery is necessarily slow, since the manufacture of money is confined almost entirely to governmental institutions, which limits the de-

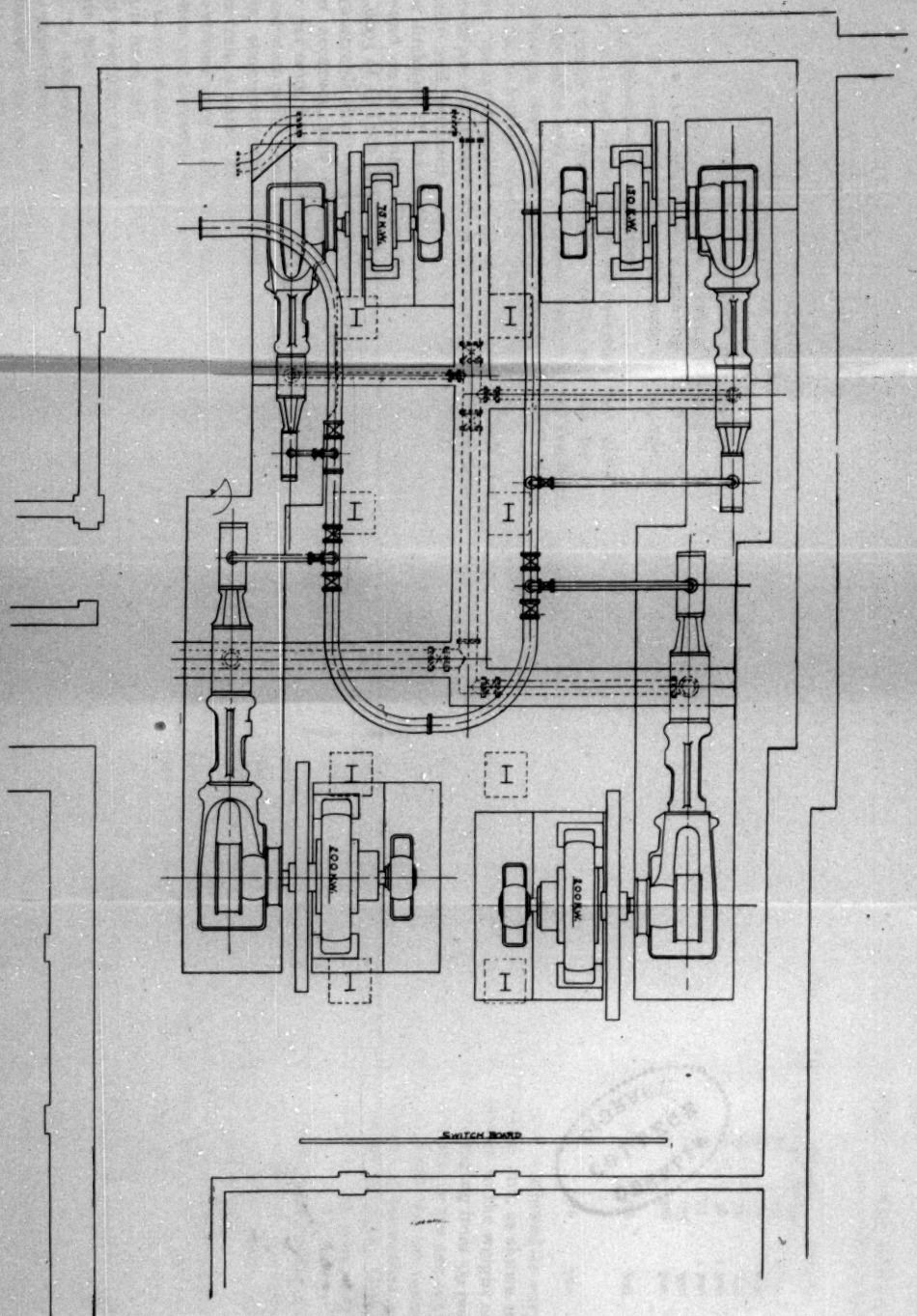


FIG. 13—PLAN OF ENGINE ROOM, U. S. MINT, PHILADELPHIA.

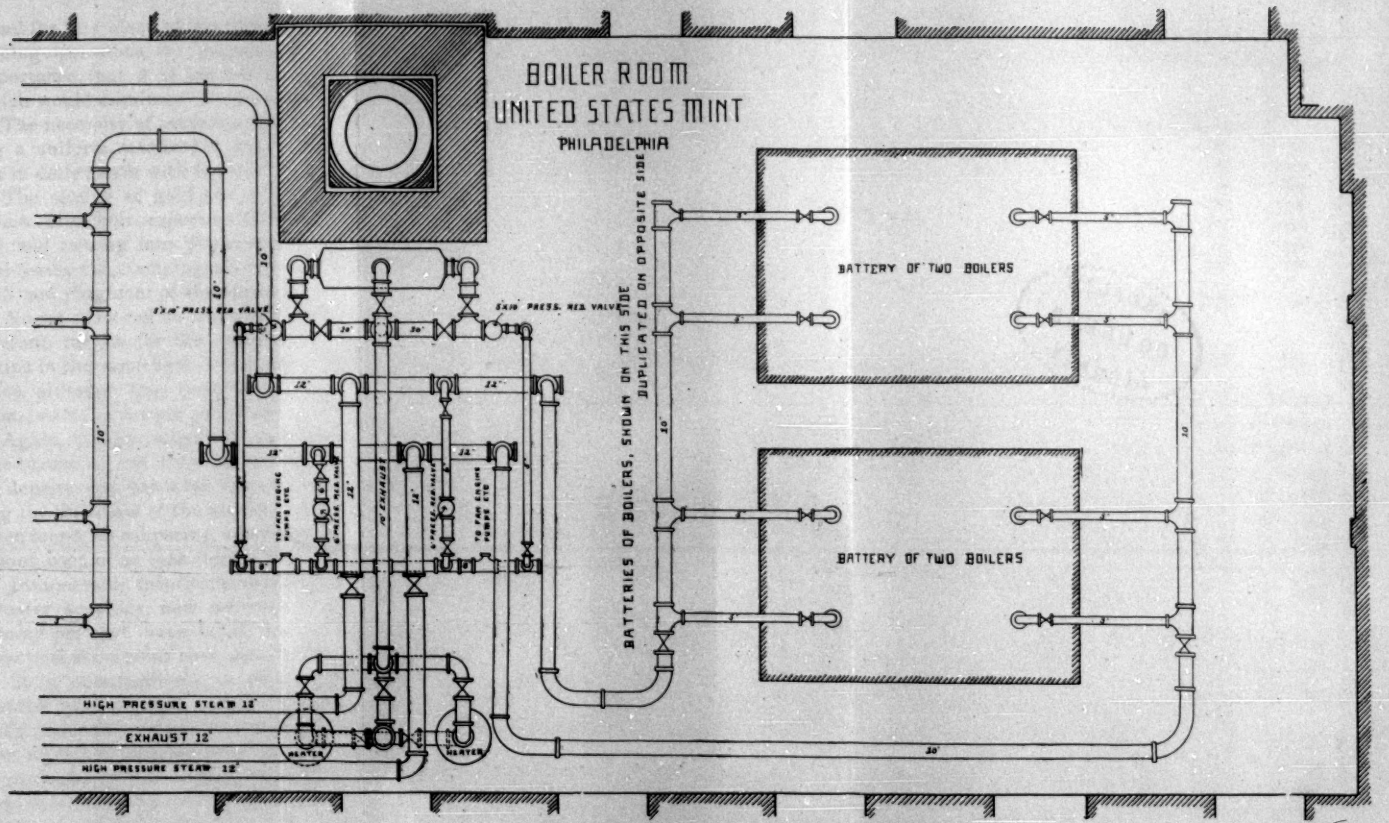
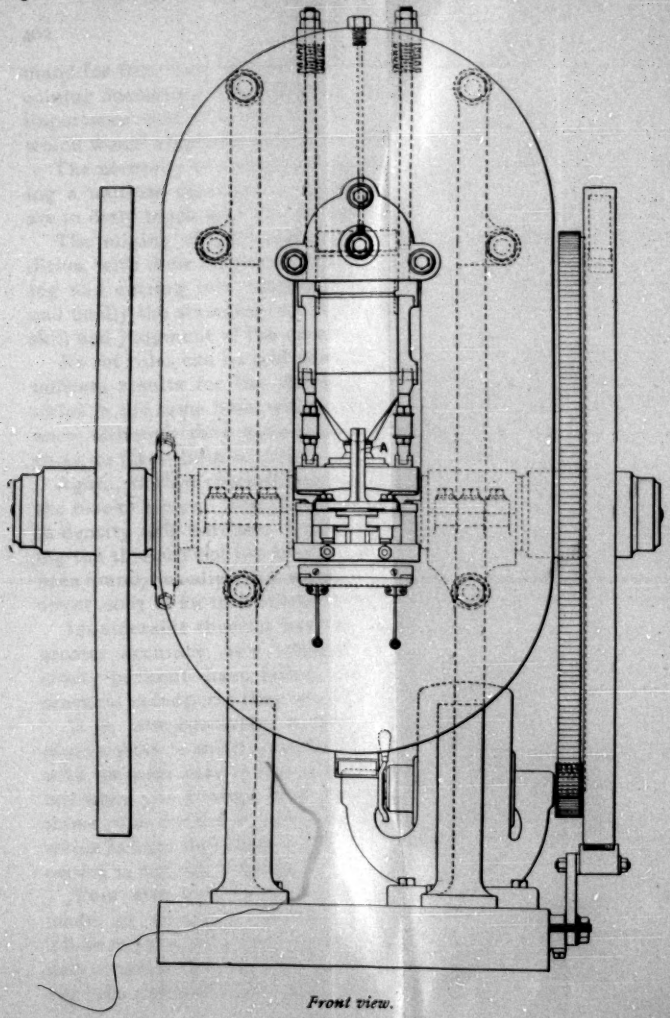
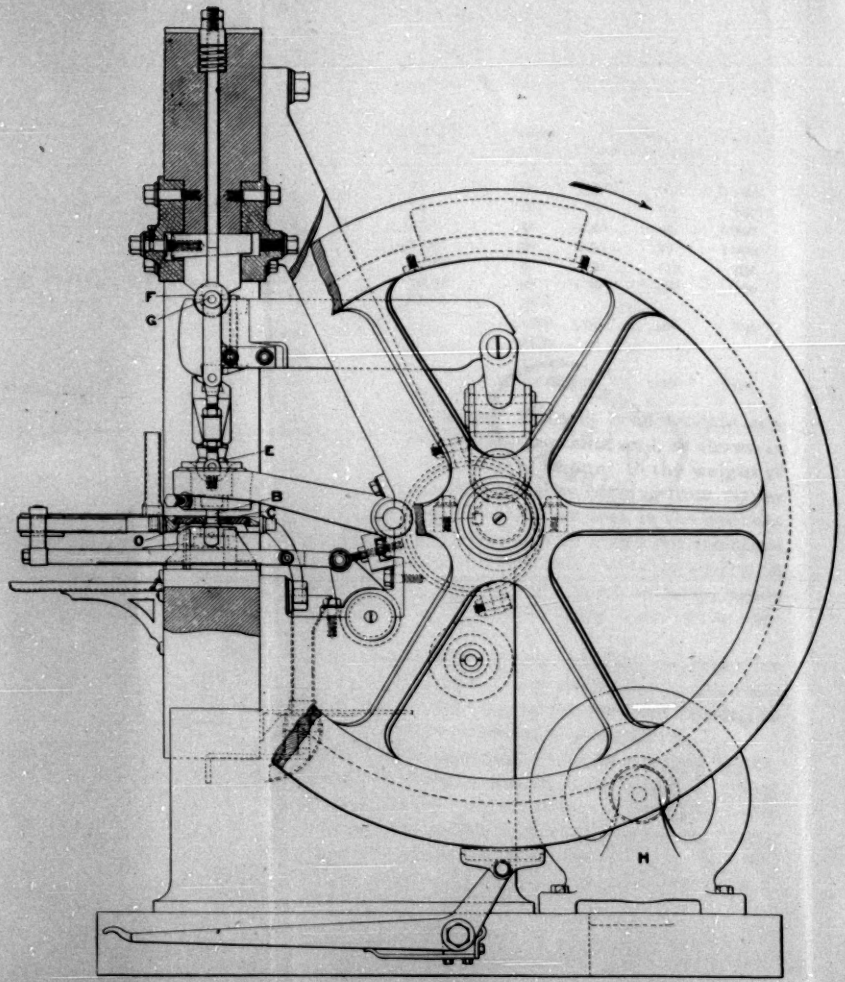


FIG. 12—PLAN OF BOILER ROOM, U. S. MINT, PHILADELPHIA.



Front view.



Side view.

FIG. 7—COINING PRESS.

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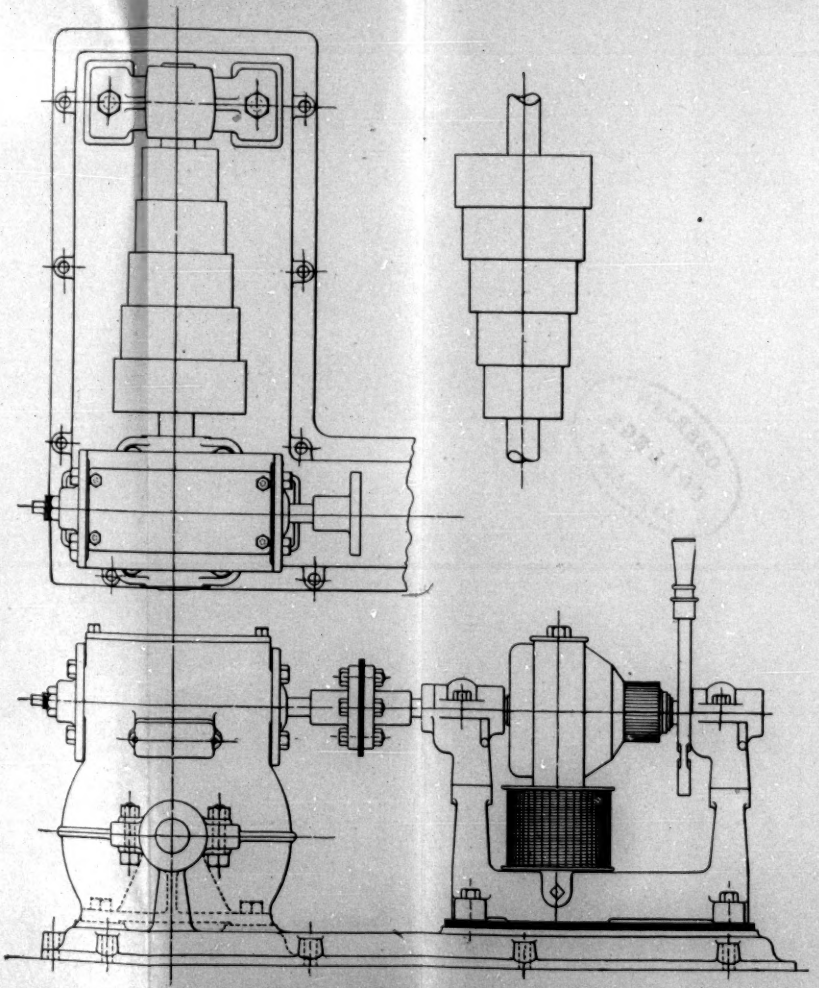

FIG. 3—WORM-GEAR DRIVE FOR THE ANNEALING OVENS.

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·09	1·350
·19	1·050
·19	·850
·36	1·500
·77	1·200
·155	·950
·388	·700
·388	·800
·416	·750

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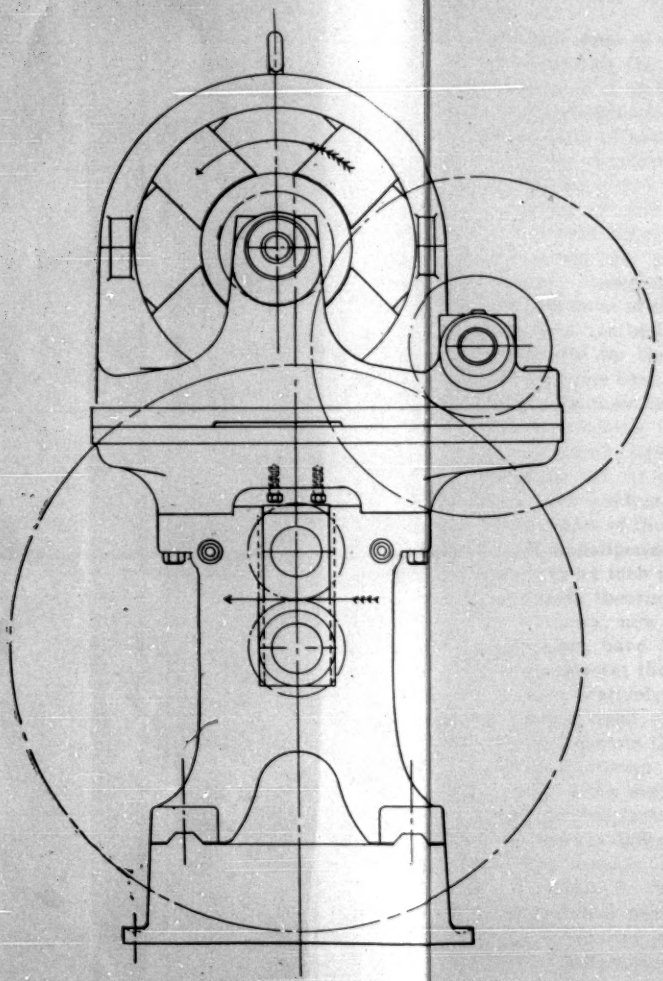


Motor end.

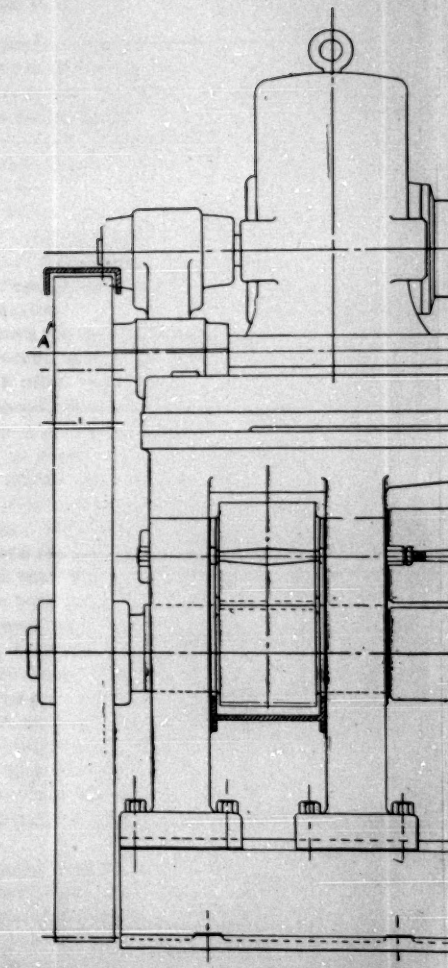
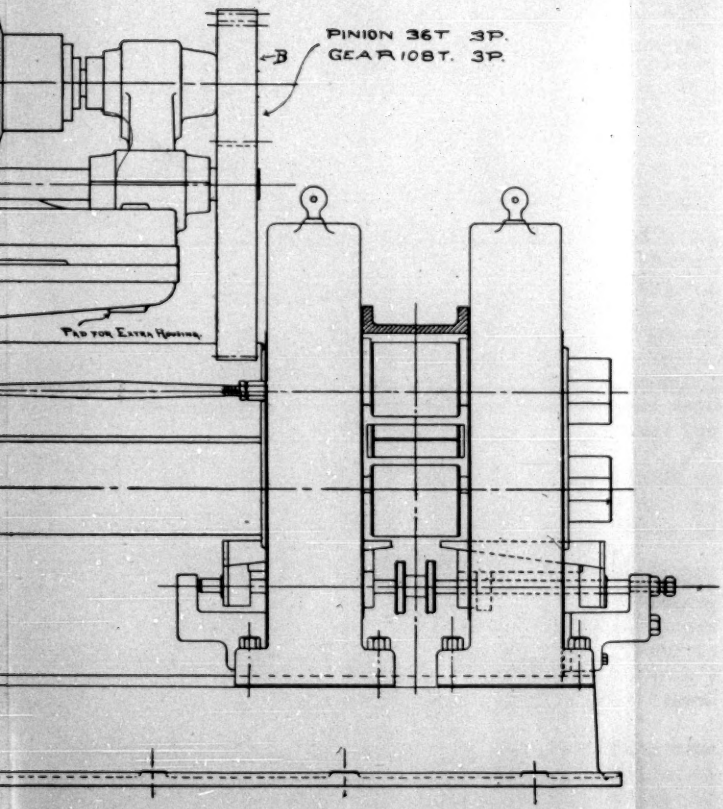
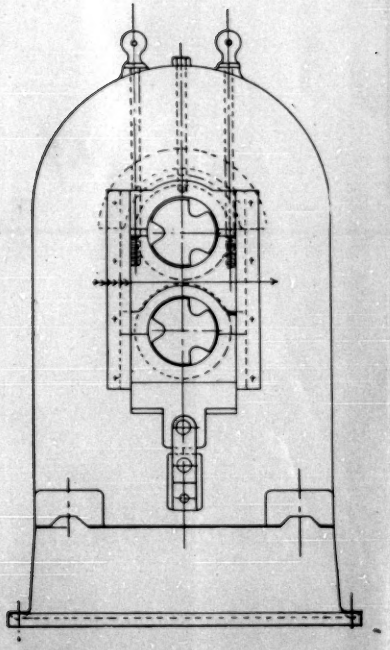


FIG. 1—10″ x 9″



Front view.



Roll end.

ROLLING MILLS, U. S. MINT, PHILADELPHIA.

mand for this class of machinery. Again, in many of the coining operations, the judgment of the operator is of such importance that it is impossible to substitute apparatus which would eliminate this personal factor.

The necessity of accuracy and the difficulty in maintaining a uniform standard is appreciated only by those who are in daily touch with the work.

The mixing of gold and silver, while in a heated condition, with their respective alloys, casting into ingots, rolling and cutting into planchets, annealing and whitening, and finally the stamping, all depend, more or less, upon the skill and judgment of the operator.

No set rules can be laid down for this work that will give uniform results for the different melts, or even for two strips in the same heat, which often vary beyond the tolerance, although they have passed through identical operations, so far as human judgment can determine.

Again, the law compels us to work by weight, and since the blanks are cut from dies of the same size, the variation in density and hardness must be compensated for by varying the thickness of the blanks. Occasionally, blanks have been found, on calipering, where the lighter pieces measured about .0003 of an inch thicker than the heavier pieces.

Innumerable theories have been propounded for securing greater accuracy, new schemes suggested and tried, but ninety per cent. have failed, because, when tested from a practical standpoint they were found to be worthless.

It is, comparatively, a simple matter to secure good results from a small amount of metal when it is handled with extreme care in the melting and annealing furnaces, but when you attempt from data secured in this manner to frame rules for the working of tons of metal daily, some of which is hard and brittle, the rest tough and soft, the proposition is entirely different.

This was forcibly illustrated when experiments were made to eliminate the draw-bench and wood furnaces. These experiments were started two years ago, and it was only recently that the results justified the adoption of finishing rolls and automatic strip furnaces for silver.

The following table gives the weight, fineness, tolerance and diameter of all pieces coined at the mint at the present time:

Denomination.	Legal Weight. Grains.	Fineness. Per Cent.	Tolerance. Grains.	Tolerance. Per Cent.	Diameter.
Double Eagle	516	90	·50	·09	1·350
Eagle	258	90	·50	·19	1·050
Half Eagle	129	90	·25	·19	·850
Standard Dollar	412·5	90	1·50	·36	1·500
Half Dollar	192·9	90	1·50	·77	1·200
Quarter Dollar	96·45	90	1·50	·155	·950
Dime	38·58	90	1·50	·388	·700
Five Cents	77·16	75Cu			
		25Ni	3·00	·388	·800
One Cent	48·	95Cu			
		2½Sn			
		2½Zn	2·00	·416	·750

The tolerance is the amount the coin is allowed to vary above or below the legal weight in grains, and, as shown in the next column, the ratio of this amount to the weight of individual pieces is a varying quantity ranging from ·09 per cent., with the double eagle, to ·416 per cent. in the one-cent piece. Of course, the denomination in which the tolerance is the largest per cent. of the legal weight, is the easiest to coin; for instance, the one cent, as shown in table, ranks first in this regard, and the double eagle is the most difficult.

Although the regulations call for a certain thickness for the various denominations, it is not considered in the coining operations, since, if the diameters are kept intact, the thickness must vary with the density of the metal.

After the metal is properly alloyed it is run into ingots, and the ends are cut off by an appliance known as a topping machine, which is run by a 3 horse-power motor; the power is transmitted from the motor to the machine by means of a belt; this, together with the cutting-presses, is the only machine used in coining operations on which a belt is used.

Four of these machines will be required.

The ingots are then rolled out by break-down rolling mills which are driven by 50 horse-power motors, and then finished to their proper thickness by mills driven by 25 horse-power

motors. These motors are arranged with countershafts, running at 300 r.p.m., through the base. The pinions *A* and *B* are made of raw-hide, in order to reduce the noise. Six break-down and four finishing mills will be used to start operations during the first year.

The mills, as shown in *Fig. 1*, have 10 x 9-inch rolls, with 7-inch necks, and are made of chilled iron.

Experiments will soon be made to substitute steel rolls, but it is a question if the efficiency will be increased enough to justify the extra expense.

These rolling mills have several features which, to the best of my knowledge, are utilized only in mint operations. The adjustment is obtained by means of wedges situated under the lower roll, which is capable of adjustment in a vertical direction, and by means of a graduated dial the movement can be adjusted to ·0005 inches. All mills will, in the future, be fitted up with the solid wabbler instead of one consisting of three or more pieces. This reduces the excessive pounding, which cannot be eliminated from wabblers of the latter type.

To determine the proper speed for rolling has been a subject of considerable experiment. Two years ago, a rolling mill was constructed so that the speed could be varied. Velocities, ranging from 40 to 160 feet per minute, were tested, and, finally, 117 feet surface velocity of material passing between rolls was adopted. Faster than this causes difficulty for the operator who receives the strip, and there is also liability of the feeder passing two strips instead of one through the rolls.

The rolling mills will be substituted for the old-fashioned draw-bench and a 25 per cent. saving in the condemned silver blank will be possible. As yet this method for the gold denomination is in an experimental stage.

The strips are then cut into blanks by cutting machines, which are driven by 3 horse-power motors. Nine of these will be used.

During the rolling operation the strips are annealed by an automatic heating machine, which propels them through an oven heated by gas, and it should be noted that the

increase of standard blanks is largely due to the efficiency of this machine.

Before leaving the mechanical operations which have been alluded to in this article, I wish to emphasize the difficulty of proper annealing, which is a source of trouble to all workers in metal, and is no doubt due, to a great extent, to the difficulty in controlling the temperature and handling the material while in a heated condition.

In most establishments less thought and time is spent in perfecting this department than any other, yet we find, in the mint, that this is the most important operation through which the metal passes.

Any process, such as forging, drawing, rolling or spinning in which the metal is subject to considerable strain or pressure, tends to harden the material in a comparatively short time, and when we consider that it requires a 50 horsepower motor to reduce a silver strip, approximately $1\frac{1}{2}$ inches by $\frac{3}{8}$ inches by 4 feet, only ·016 inches during one passage, it would seem strange indeed if a considerable molecular change could not be detected. To restore the ductility to the metal, a constant temperature of the proper degree must be maintained, and without going into detail respecting the requirements of the various metals, the following is a general scheme which shonld be followed:

The proper degree of heat for the various metals must be distributed over the surface without relying upon the conductivity of the metal for equalization, and the flame must be non-oxidizing when gold or silver is to be worked with their alloys.

The work at the mint has shown that the old idea of annealers to allow the metal to "soak," after it has been brought up to its proper heat, is of no benefit, especially where the fineness has to be maintained within the government limits; the material should be withdrawn as soon as heated.

Gold is now annealed in the automatic furnaces by remaining in the flame approximately seven minutes—that is the time required in passing through. The wood furnaces required a strip to remain in the fire about forty

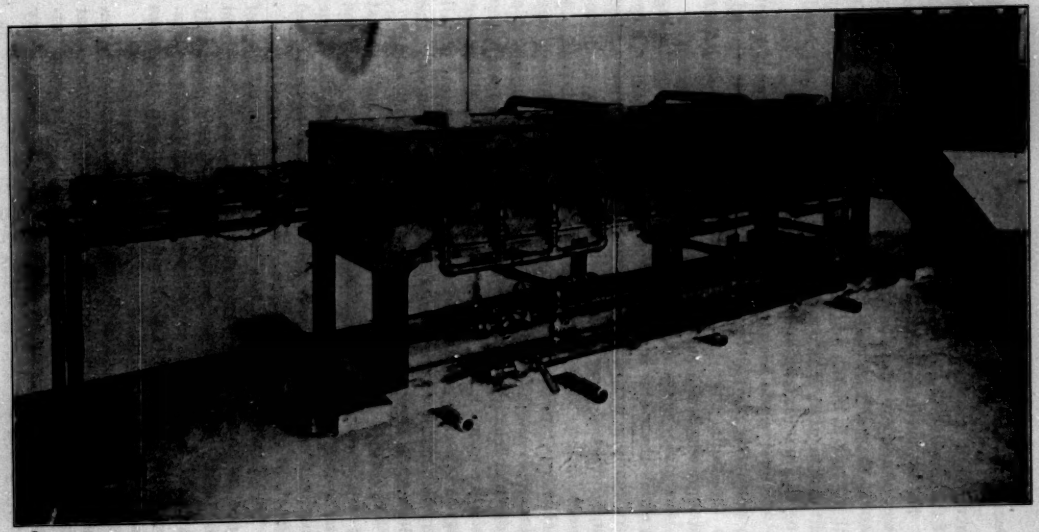


FIG. 2—Annealing furnace.

minutes. *Fig. 2* is a photograph of the first machine built of this kind, and is similar to the new ones, except that the cooling attachment is not shown. Instead of the strips being cooled by hand a fine spray of water is thrown upon them before they are exposed to the air, which prevents oxidization. They can then be handled without gloves or tongs.

The heating machine will be driven by ½-horse-power motor, and the variation in speed is secured by means of cones which run at 120 r. p. m. The reduction of speed is obtained by worm and worm wheel, as shown in *Fig. 3*.

The blanks are then upset by a machine, as shown in *Fig. 4*, driven by a 3 horse-power vertical motor. Nine of these were designed and built at the mint.

The planchets are then annealed by rotary-heating machines and cleaned with a diluted solution of sulphuric acid.

The furnaces are driven by ¼ horse-power motors geared into a shaft passing through a cone, and the power is transmitted to furnace by means of a belt. This scheme is shown in *Fig. 5*.

The rotary-heating machine (*Fig. 6*) consists of a wrought-iron cylinder surrounded by a cast-iron cylinder. The metal is carried through the outer cylinder by a worm and then dropped, in a heated condition into a receptacle and is ready for the bath.

The planchets, after the cleaning operation, are stamped. This is done by means of the coining press, which is, without doubt, one of the best-designed machines in the building, and is shown in *Fig. 7*.

The planchets are fed in the tube A by the operator, and placed in collar O by means of the fingers. The end of the travel of fingers is shown by the dotted position, L. The fingers are opened and closed at the end and beginning of the stroke by means of the friction-block, which travels in grooves.

The upper die, B, actuated by the horizontal beam through the toggle, gives the obverse impression, while the lower die, C, imprints the reverse side. As the dies come

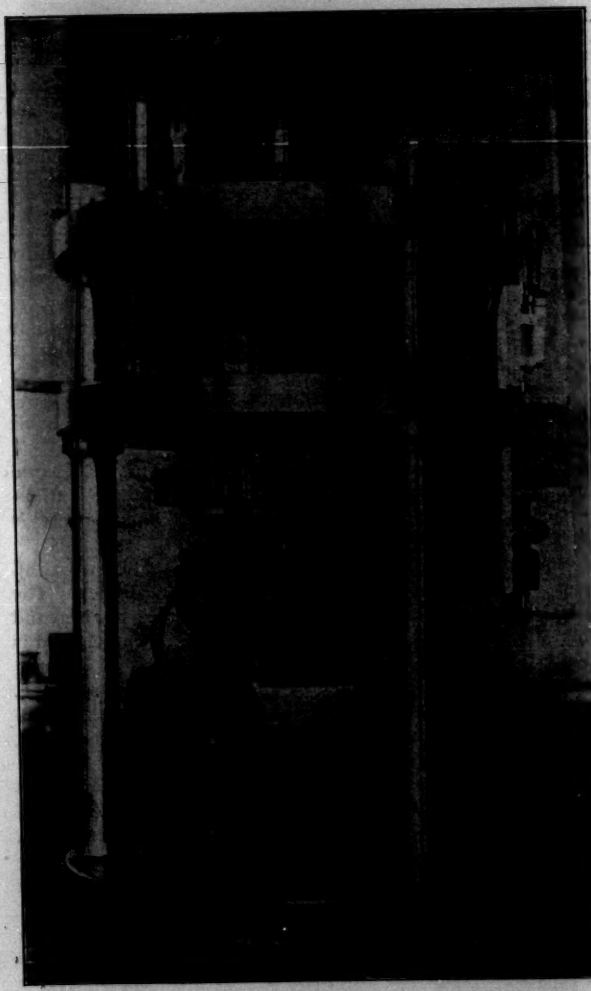


FIG. 4—Upsetting machine.

together the metal is pressed in the grooves of collar, C, giving the reeding on the outer edge. After the stamping operation is completed the fingers return to their first position, J, and on feeding the next planchet pushes the stamped coin aside, which has been forced out of the collar by the raising of the lower die.

On account of the excessive pressure amounting approximately to 160 tons for a dollar, the bearings of the toggle must be very hard, and lapped to a proper bearing.

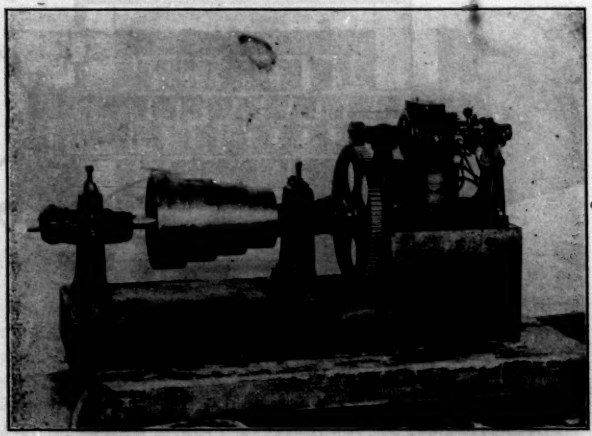


FIG. 5—Geared speed-reducer.

Twenty-three coining presses are to be installed: the larger ones, capable of coining all denominations, will be equipped with 7½ horse-power motors, and the small presses, which are used for denominations up to and including quarter dollars, are equipped with 3 horse-power motors.

The above is only a general description of minting operations, omitting the automatic weighing machines, adjusting, ringing, or the test for resonance, and the several

precautions necessary to preserve the standard of excellence expected of the Mint.

As a result of the new annealing operations, a noticeable change has been observed by the mint officials in the color and appearance of the gold coins. This effect is due to the naphtha gas flame, which does not oxidize the copper used as an alloy, consequently the gold has a much deeper color, preserving the true color of the government alloy.

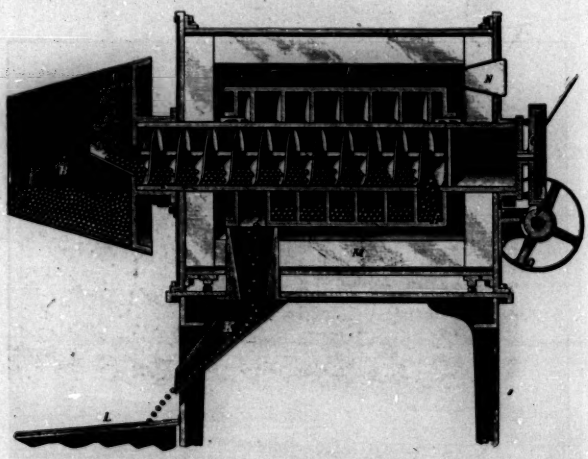


FIG. 6—Rotary furnace.

These improvements in annealing are due to the efforts of the American Gas Furnace Company, of Elizabeth, N. J., the coöperation of the Treasury officials and the determination of the Superintendent of the Mint to secure the best equipment possible for the new building.

The following is the number and size of the motors which will be used for coining operations:

	H. P.		TOTAL H. P.	
3	— 3	—	9	open-type countershaft through base.
4	— 7½	—	30	" " " " "
1	— 15	—	15	" " " " "
2	— 25	—	50	" " " " "
1	— 35	—	35	" " " " "
6	— 50	—	300	" " " " "
14	— 7½	—	105	" "
34	— 3	—	102	" "
1	— 10	—	10	" "
2	— 15	—	30	" "
1	— 5	—	5	" "
4	— ¼	—	1	" "
12	— ½	—	6	" "
2	— 10	—	20	enclosed type.
2	— 20	—	40	semi-enclosed type.
1	— 12	—	12	" " "
4	— 10	—	40	" " "
2	— 10	—	10	" " "
1	— 3	—	3	" " "
1	— 5	—	5	open reversible.
2	— 3	—	6	" "
1	— 10	—	10	suspended from ceiling.
1	— 5	—	5	" " "
9	— 3	—	27	vertical type.
111			876	

SPECIAL CONNECTED MACHINES.

There are two directly connected sets. Capacity of dynamos, five hundred ampères at 5 volts each; fields to be excited from 220 volts.

The following are a few special motor connections: *Fig. 8*, 30 x 30-inch x 6-inch planer; *Fig. 9*, milling machine; *Fig. 10*, 24-inch lathe; *Fig. 11*, blower for gas purposes.

On account of the 220 volts which are used for power and lighting purposes, the starting boxes for all motors except those for 50 horse-power are provided with magnetic blow-outs, overload, and no voltage release. The contact buttons are also staggered.

The boiler plant as shown in *Fig. 12* consists of eight boilers, 150 horse-power each, arranged in four batteries carrying 125 pounds pressure and equipped with down draft furnaces. The gases from boilers can be passed through fuel economizer to an exhaust fan or directly to chimney.

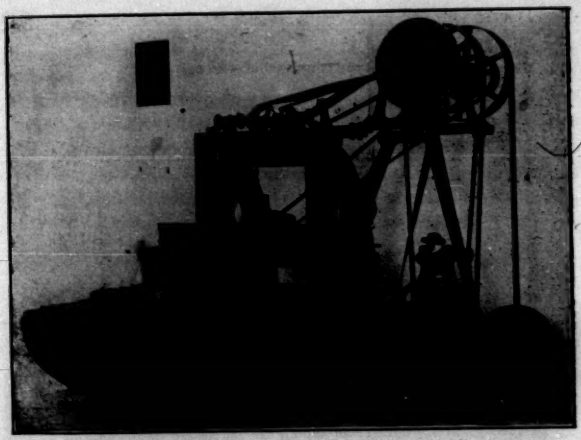


FIG. 8—30″ x 30″ x 6′ planer.

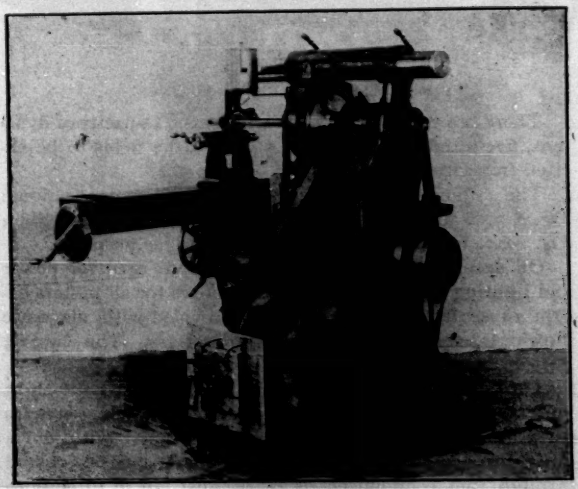


FIG. 9—Milling machine.

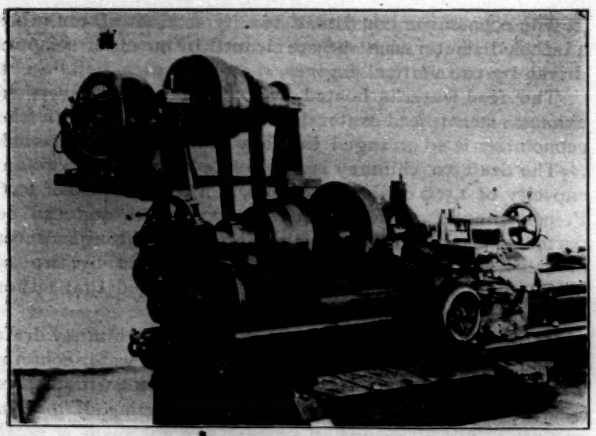


FIG. 10—24″ lathe.

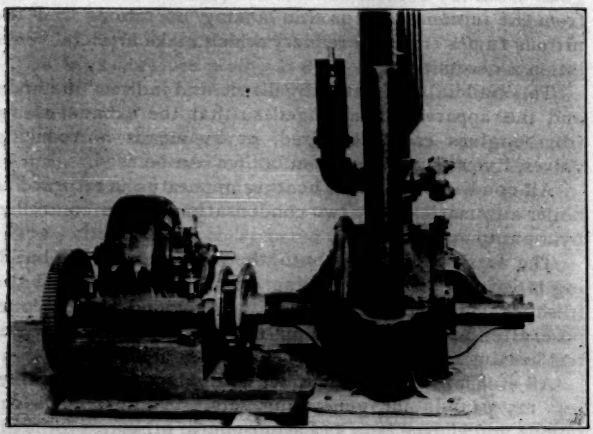


FIG. 11—High-pressure blower.

The economizer consists of twenty sections of ten tubes 4 inches diameter each and are cleaned by means of scrapers driven by two vertical engines.

The feed water is heated by a 700 horse-power vertical exhaust steam feed water heater, and together with the economizer is so arranged that any or all can be by-passed.

The draft to chimney is augmented by an 8 foot fan, capacity of 2,500 cubic feet of gas, at a temperature of 300° F. per minute. The fan runs at 200 r.p.m. and can be parted at an angle of 45° to the horizontal through center of shaft, to facilitate repairs. It is driven by two 25 horse-power vertical engines and so arranged that either one can be thrown into service.

There is also provided a steam nozzle for chimney draft capable of giving a draft equal to 1 inch of water column. The amount of draft is regulated by damper regulators connected to steam drum and also by throttling of the fan engines.

The chimney will not only be used for disposing of gases from the boilers, but also the products of combustion from the furnaces, etc. used in coming operations and the nitrous fumes from the refinery which make artificial ventilation a necessity.

The building is heated by direct and indirect methods, and the apparatus is arranged so that the exhaust steam from engines can be utilized, or by means of reducing valves, live steam direct from boilers can be used.

All condensation from heating apparatus is returned to boiler automatically by two condensation pumps controlled by a pump governor.

The fresh hot-air supply to the various rooms in building is introduced after passing over heated coils, and the fresh air is taken through openings provided for that purpose, after passing through air filters and delivered to central heating chamber by means of fans.

All steam piping is in duplicate, and arranged for carrying 125 pounds for generating sets, seventy pounds for pumps and engine fans and atmospheric pressures for heating system.

Two steam horizontal condensation pumps, 7½ x [illegible] x 6 inches, and two vertical boiler feed pumps, 9 x 6 x 6 inches, are installed with their respective piping, so that any or all can be used.

The generating plant consists of four direct connected generating sets, as follows:

Two 200 kilowatts, 100 r.p.m.; one 150 kilowatt, 135 r.p.m.; one 75 kilowatt, 150 r.p.w.

The engines are of the tandem, compound, non-condensing Corliss type, connected directly to their respective generators, and their guaranteed efficiencies are as follows:

200 kilowatts, 21½ pounds of water for indicated horse-power per hour.
150 kilowatts, 22 " " " " "
75 kilowatts, 23 " " " " "

The two 200 kilowatts are to be used for coining operations during the day, the 75 kilowatts for night work, and the 150 kilowatts for lighting purposes. Practically, no provision is made for gas-lighting in the new building, and it will be necessary for the power plant to supply current at all hours of day or night.

Fig. 13 shows the general arrangement of the various sets.

The high-pressure piping is designed so that steam can be shut off any engine without interfering with the remaining sets.

The connections between the generators and switchboard are made by lead-encased, rubber-insulated cables, carried in ducts varying in size from 450,000 circular mils to 1,200,000 circular mils.

The switchboard is constructed of pink Tennesse marble, 2 inches thick, and is divided into panels, as follows: Four for generators, two for lighting circuits, and the remainder for the motor circuits throughout the building. The bus-bars for lighting and power circuits can be used independently, or by means of a switch can be connected. Double-throw switches enable the operator to throw generators on either lighting or power circuits. For the power circuit the circuit-breakers are of the one-throw type, consisting of two arms connected together, and switches are used in conjunc-

tion. The lighting panels have the independent arm, double-throw-type circuit-breaker, and are used without switches.

As far as possible each department has its independent system for power purposes, and as the coining operations consume the major portion of the power, the rolling room alone is supplied with four independent circuits capable of delivering over 500 horse-power. This room is equipped with the 50 and 25 horse-power motors, together with the 3 horse-power motors for the cutting presses.

Twenty-five feeders supply current for approximately 3,500 lights, the majority of which are 16 candle-power and about 400, 32 candle-power. Each of the feeders is supplied with a switch, or the entire lot may be thrown out by pulling one main switch.

Fifty-one telephones connected to a switch board controlled by an operator are installed. The system is of the complete central-energy type, and the operator is notified of a call by the dropping of a shutter connected to its respective phone.

An ink-writing telegraph register, capable of indicating an alarm from any one of thirty-five alarm boxes, is used in connection with fire-alarm gong in the office of the engineer and of the superintendent of machinery. The taps on the gong correspond to the station from which the signal is sent.

Thirty watchman's clocks are placed in various parts of the building for the protection of the immense amount of metal stored in the form of coin or bullion.

The signals are turned in by means of a handle causing a small dynamo at each station to send a current to its respective magnet.

Forty-one time-clocks, connected to a master-clock are installed in order to secure uniform time throughout the building.

A switch-board built of blue Vermont marble mounted on an iron frame-work is located in the guard's room in the basement.

On this board is mounted the fuse block, telephone wir-

ing, fire alarm recorder, American District and Western Union call-boxes, police-telegraph and city fire-alarm boxes and voltmeter switch for testing condition of the various storage batteries which supply the electrical apparatus throughout the building.

The storage battery plant, which is in duplicate, supplies the telephone exchange, fire-alarm system and time-clocks with current.

The battery consists of sixty cells connected to a circuit-changing switch, so that when the switch handle is thrown in one direction thirty of the cells will be thrown in series and made ready for charging. The other thirty are split up in five groups with different members of cells in each group: one supplying the telephone exchange; another, fire-alarm system; third, the gas machine; fourth and fifth, the time-clocks.

The circuit-changing switch is thrown in the other direction when the batteries are discharged, placing the duplicate set in service for the various apparatus.

The scheme for charging is arranged so that it can be done from one of the power panels in engine room which is equipped with circuit breaker and rheostat.

Eight elevators, seven for freight and one for passengers, driven by electric motors and provided with a top-and-bottom limit switch, slack-cable switch, safety switch in car and centrifugal governor, all being in series with the brake magnet and safety cut-out.

Four of these elevators, having a capacity of four tons each, are to be used for carrying the loaded trucks of metal to the various floors, and one is so arranged that by means of a back gear the speed can be reduced and its capacity doubled. This will be used for transferring heavy coining machinery varying in weight from three to seven tons.

The gas equipment includes furnaces, heating machines, etc., throughout the building, and a gas-generating plant.

The installation consists of two independent plants; the larger one has a capacity of 20,000 cu. ft. of gas per hour, has four generators arranged in two sets, and each set in turn is connected in tandem.

The smaller plant is to be used for the assay department, and has a capacity of 2,000 cu. ft. of gas per hour. This plant, in case of necessity, can be thrown in service with either one of the larger ones.

This system manufactures gas by vaporizing naphtha in the presence of warm air, and all the accessories to the vaporizer or generator are simply to keep the pressure and temperature of gas constant by heating the oil, air, and the gas after passing from the generator.

The accessories consist essentially of a feeding tank, which regulates the supply of oil to the generator; water-pressure regulator for forcing the oil from the storage to the feeding tank under constant pressure; the circulating pipes for heating the oil after it passes through the generator; the radiator for governing the temperature of the oil which circulates in the machine; the automatic cut-off, the function of which is to close instantly when the air-pressure is removed; the gas-discharge valve for starting the machine, and an air-supply valve for controlling the air to the pipes which connect with the spraying nozzle in the generator.

A thermometer in series with a storage battery and special valve controls the steam to heating chambers. Four storage tanks, with a total capacity of 32,000 gallons of naphtha, are buried below the basement floor for supplying the various machines with oil.

The number of pieces coined and value of same varies considerably in different mints and depends somewhat upon the local conditions. For the fiscal year ending June, 1900, the Philadelphia Mint coined 152,558,878 pieces, value of which was $71,378,477.61. The total coinage of all the mints was 184,373,793 pieces valued at $141,351,960.36. The coinage of nickel and bronze is confined to the Mint at Philadelphia, and 101,301,753 pieces of the value of $2,243,017.23 were manufactured.

There is also considerable special work required, and during the same year 50,000 Lafayette souvenir silver dollars and 320,000 pieces in 20, 10 and 5 colones for the government of Costa Rica were stamped.

The Director of the Mint states that the chief increase of coinage for last year was in the subsidiary and minor coins, which surpassed all records and was no doubt due to the extraordinary activity of the retail trade throughout the country.

To handle such a vast quantity of metal, which in a year amounts to tons, not only becomes a mechanical problem but necessitates an elaborate system of checking, weighing, assaying and calculating.

The transportation of metal has grown to large proportions, and the Director of the Mint reports that for the last fiscal year the imports in gold and silver amounted to $79,829,486.00 and the exports $104,979,034.00. This was in the form of bullion, ore and coin (both foreign and domestic.) The handling of coin causes considerable wear, and last year the loss to the government in recoining $6,662,524.85 in worn and uncurrent coin was $313,334.21.

The care of all this money gives an endless amount of trouble. Huge steel vaults for its storage, equipped with all manner of safety devices, must be under constant surveillance. In the new building the largest and most improved vaults in the world are situated under the front running from 16th to 17th Streets.

Each vault has three doors: the front door, weighing about eight tons, is mounted on ball bearings; the other two doors are arranged in one set and are somewhat lighter than the front one. Four combination locks are used, which can be adjusted to independent combinations.

But with all these appliances for the safety of the many millions, the government must depend more or less on the honor of its employés. Considering the number of men employed, the vast quantity of precious metals handled, it is remarkable how small an amount has been lost.

SOME CHEMICAL MYSTERIES.

It has happened more than once that just as we had firmly established our science upon a basis which seemed as unyielding as the Biblical rock, and had toilfully formulated theories that explained all phenomena with unvarying simplicity, some obscure experimentalist made a discovery which by no

possibility could be twisted and molded to fit the existing system and, indeed, even challenged the truth of all established doctrines. Thus it was that Young and Fresnel overthrew the old emission theory of light with their experiments in the phenomena of interference; and thus our theories of chemical interaction, and even our conception of matter, may be modified by the researches made within the last five years in the field of the radio-active substances.

What chemist formerly would for a moment have thought of attacking the law of Avogadro—the law which tells us that if the temperature and pressure be equal, equal volumes of different gases contain the same number of molecules? And yet a modern chemist, Lord Rayleigh, did find it necessary to test the truth of that law by precise determinations of the densities of well-known gases. If he had never studied the behavior of nitrogen, or if he had considered the discrepancies which he observed in determining the vapor-density of that gas, as errors due to defective observation, as many a chemist before him had done, argon and the other newly discovered constituents of the atmosphere might still be unknown, and many chemical doubts never aroused. Roentgen, too, found it necessary to revive theories of radiant matter which we thought we had long since refuted, and he supplied us with rays which we cannot yet explain. Becquerel increased our perplexity with his thorium and uranium rays. But when M. and Mme. Curie exhibited to our astonished eyes the results which they had achieved with radium and polonium, we were completely mystified and were compelled to admit that there were more things in chemistry than our philosophy had dreamed of. Other chemists have also experimented with uranium, following methods different from those of the Curies, and have obtained additional active substances.

Still another supposed element has been found to mock our periodic system. It has been discovered that thorium, when subjected to the action of acids, yields helium, and that thorium is often associated with radio-active substances.

Helium and its gaseous companions on the one hand, the radio-active substances on the other hand, are mysteries which have so far completely baffled our chemists. And uranium and thorium, elements with which we once considered ourselves thoroughly familiar, are now to us as curious as if they had been but the discovery of yesterday.

If the eccentricities of uranium, thorium and helium, and the mysteries of Roentgen rays cannot be adequately accounted for by our existing chemical system, the question arises: Can our system be wrong? Chemistry is an exact science—at least we had flattered ourselves that it had been at last raised to that eminence. But an exact science is infallible, and will hear nothing of exceptions. Some day a chemist will be found whose mind, broad enough to grasp the scattered facts unearthed in the course of a century of research, will elaborate a chemical system which may prove as revolutionary in its way as the theory of Young; but which will embrace in its comprehensiveness those puzzling gases and radiant substances so utterly inexplicable at present.—*Scientific American.*

AN INVESTIGATION OF THE COST OF POWER.*

By Clyde D. Gray.

(*Concluded from p. 413.*)

PRODUCER GAS.

Kind, Composition.	B. T. U. per Cu. Ft.	Authority.
Dowson, H-18 : CO-25	143	Poole.
" " 19 " 35	108	" Anth. coal.
" " 17 " 25	147	" Bit. coal.
Siemens	120	"
Ordinary producer	150	Reichelm, *Am. Ma.*, Jan. 10, 1901.
Dowson	160	*Elect. Eng.*, Jan. 25, 1901.
Mond, bituminous coal	155	
Ordinary	135	Donkin, *Eng. Mag.*, Dec., '00.
Siemens	140	Galloway.
Ordinary, heated	156	Webster, *Cass. Mag.*, 13-293.
" Taylor	140	Kerr, " " 18-425.
Anthracite coal	137	Taylor, A.I.M.E., 18-859.
Bituminous "	157	
Ordinary	150	Roberts.
Average	143	

BLAST-FURNACE GAS.

Ordinary blast-furnace	100	*Elect. Eng.*, Jan. 25, 1901.
" "	110	Donkin, *Eng. Mag.*, Dec., '00.
" "	98	Kerr, *Cass. Mag.*, 18-425.
" "	100	Booth, " " March, 1901.
Average of all	102	

The preceding tables give an idea of the relative heat-values of the different kinds of gas. The amount that can be made from a ton of coal is variable and depends upon the kind of coal and the process by which it is made. Perry, in a paper before the A.I.E.E., in 1894, estimated that the better grades of coal, when used in a Dowson producer, would produce about 160,000 cubic feet of gas.

GAS-ENGINE TESTS.

The following tables contain some tests of different gas-engines using various kinds of gas. Some of these are

* From thesis presented for the degree of master of mechanical engineering. Sibley College, Cornell University. 1901.

small and others large, although there are but few tests of the larger sizes, from the fact that they have not been on the market until recently. The amount of gas used per horse-power is in some cases based upon the indicated, and in others upon the developed or brake, horse-power. This is indicated by an *i* or *b* placed after the column.

USING NATURAL GAS.

Kind.	H. P.	Cu. Ft. per H. P.	Authority.
Westinghouse . .	621	9·3 (i)	Miller & Gladden, *Sib. Jour.*, June, 1900.
" . .	67	10·4 (b)	*London Engineering*, Jan. 4, 1901.

The Westinghouse Company will guarantee a gas consumption of 12 cubic feet gas per B.H.P. on their small engines and as low as 10 for the larger sizes. The Standard Automatic Gas Engine Company guarantees less than 15 cubic feet per B.H.P.

USING COAL GAS.

Kind.	H. P.	Cu. Ft. per H. P.	Authority.
Westinghouse . . .	9	14·5 (i)	Budd & Moody, Sibley thesis.
Springfield	12	16·5 "	Spier & Keely, " "
	10	15·5 "	Perry.
		16·6 (b)	*Lond. Eng.*, Jan. 4, 1901.
Campbell		15·4 "	Donkin, *Eng. Mag.*, Dec., 1900.
Otto-Crossley	17	24·1 "	
Clerk	9	30·4 "	
Atkinson, differential,		25·7	
" cycle . . .	6	22·5	
Griffin	16	28·5	
Forward	6	22·5	London *Elect. Eng.*, Jan. 25, 1901.
Simplex		20·4	
Wells Bros.	12	27·8	
" "	18	21·0	
Premier	61	19·7	
	50	17·0 (i)	
Railway plant . . .	31	21·0 (b)	Hill & Brocksmit thesis.
Average on B. H. P. .		22·9	

This average is rather higher than can be expected of the best modern engines, for these are all rather small units. About 17 or 18 cubic feet may be expected of the average modern engine of moderate size.

USING PRODUCER GAS.

Kind.	H. P.	Cu. Ft. per H. P.	Coal Lbs.	Authority.
Crossley	142	65·7 (i)	·92	*Lond. Eng.*, Jan. 4, 1901.
Koerting	349	83·2 (b)		Mond gas, Jan. 4, 1901.
	377	60·1 (i)		
Diesel	7		1·31	
"	170		·88	Dowson gas, Jan. 4, 1901.
Simplex	220	86·8 (b)	1·30	Witz, Dowson gas.
"	59	77·7 "	1.30	
			Less than.	
Otto			2·00	Dowson gas.
Simplex	220		·80	*Lond. Eng.*, Nov. 30, 1894.
Crossley	280		1·03	Richmond, *Eng. Mag.*, 10-853.
Otto		(i)	·95	Spangler, *Cass. Mag.*, 9-47.
Crossley		"	·76	
La Tombe		(b)	1·60	*Power Quarterly*, 1901.
	100	(i)	1·03	Adams, *St. Ry. Jour.*, June, '00.
	320	"	·81	
Crossley-Otto	28	"	1·41	*Trans.* I.C.E., 5-73.
"	118	"	·76	
Atkinson	22	"	1·06	
Stockport	76	"	·86	
		109 (b)	1·25	Adams, *Eng. Mag.*, 16-513.

Average of those on I. H. P., 1·04

Average cubic feet on B. H. P., 82, or on I. H. P., 62·9. These values are only approximate, as the data is not very complete.

USING BLAST-FURNACE GAS.

Kind.	H. P.	Cu. Ft. per H. P.	Authority.
Cockerill	182	116·5 (b)	Donkin, *Eng. Mag.*, Dec., 1900.
"	650	135·7 "	
"	725	101·0 (i)	
Ottotype	79·5	79·4 "	
	175	145·2 (b)	Booth, *Cass. Mag.*, Mar. 9, 1901.
Wishaw, Eng.		140·0	
Cockerill	661	112·9 (b)	Hubert, test at factory.
"	715	102·3 "	
Acme	15	90·0 "	"Colliery Guardian," quoted in *Eng. Mag.*, 15-140.
Cockerill	575	111·4 "	*Eng. Mag.*, 19-587.
Same with blower		101·0 "	
Frieden	177	133·0 "	Schutte.
	90	231·0 "	
	100	91·0 (i)	
Average		115·1	

Blast-furnace gas is a very good fuel and is very cheap because it is a wasted by-product. It has been used to raise steam under boilers and the steam used in turn to drive the auxiliary machinery and blowers that are necessary in blast-furnace operation. The gas-engine is coming into use for this purpose, especially in Europe, where some very large ones have been made and installed.

OIL-ENGINE TESTS.

Kind.	H. P.	Lbs. Oil per D. H. P.	Kind of Oil.	Authority.
Campbell . . .	40	·85		
Blackstone . .		·78		
Standard aut. .		·62	Gasoline	*St. Ry. Jour.*, June, 1900.
Banki	25	·53	Benzine	Meyer, *L. Eng.*, Dec. 30, 1900.
"	26	·48	"	
Springfield . .	6	1·67	Gasoline	Spier & Keey, Sib. thesis in 1900.
Diesel	33	·46	Petroleum	*Lond. Eng.*, Dec. 30, 1900.
Priestmann . .		1·20	Kerosene	Guy, "El. Light and Power."
Dopp	10	·43	Petroleum	*Eng. Mag.*, 18–124.
Banki		·46	"	
Mietz & Weiss,	10	·62	Kerosene	*E. W.*, April 10, 1901.

No average can be taken from this table, as the engines tested are of such different sizes and makes, as well as using different kinds of oil. It may be assumed that the use of gasoline or kerosene is less economical than the use of gas. There are cases, however, where it is necessary to use them, in places where gas cannot be procured, or for portable engines that are to be used in isolated plants, or on boats or carriages. The gas-engine using gasoline fuel is therefore a standard form of machine, works very nicely, and is fully as reliable as those using gas.

COST OF GAS POWER.

The cost of power generated by gas-engines is variable and depends upon the kind of gas used, the size of engine, the character of the load and the cost of the material used as fuel. The following table gives some figures on the cost of power produced by different sized engines using the different fuels. The kind of gas used is indicated by a small letter in brackets as well as whether the horse-power is based upon the indicated or brake.

Kind, Place.	Cu. Ft. Gas.	Coal per H. P.	Cost Cts.	Authority.
		1·00	1.00 (b. p.)	*Elect. Eng.* Jan. 25, 1901.
	17		1.62 (b. c.)	
Ordinary . . .	20		.87 (b. p.)	
	23		1.50 "	Guy, "Electric Light and Power."
Schwabing . .		1·50	1.50 "	
" . .			3.00 (b. c.)	
Otto		1·20	.16 (i. p.)	Cost fuel alone, Robinson, "Gas and Petroleum Engine."
Ordinary . . .	200		·56	Eberle, *Eng. Mag.*, 14–687
	250		2.00 (b. p.)	*Elect. World*, 1897, p. 822.
Clausthal . . .		1·73	"	" " 36–457.
		·93	.90 "	Cassier's, 9.
Average engine,			.50 (b. n.)	Kerr, *Cass. Mag.*, 18–425.
	20		2.00 (b. c.)	
Glascow . . .		1·25	(b. b.)	Fuel alone, 18–425.
Ordinary . . .			2.00 (b. c.)	Bolton, A.S.M.E., 20–873.
Average . . .			2.40 (i. c.)	Krone, Dg., *E. W.*, 1900, p. 443.
Crossley . . .		2·05 per K. W.		*Eng. Mag.*, 15–295.
LaTombe . . .		1·60		
Otto		1·00	(b. p.)	
Charon		1·06	"	*Power Quarterly*, Oct., 1900.
Crossley . . .		1·23	"	
Oil engine . .			1.74 (b.)	Guy, "El. Light and Power.
Gasoline engine,			1.50 "	Kerr, *Cass. Mag.*, 18–425.
Diesel			2.00 "	
Ordinary . . .			.66 (b. b.)	Meyer, *Sci. Am.*, Feb. 9, 1901.
" . . .			.83 (b. p.)	
" . . .	25		3.10 (b. c.)	*West. Elect.*, Feb, 23, 1901.
Blast-furnace .	80			Dg., *E. W.*, Jan. 19, 1901.

The letters in the brackets are read as follows: The first one refers to brake or indicated horse-power and the second to the kind of gas used, either natural, producer, coal or blast-furnace.

The costs of gas-engine plants are not very different from those of steam plants. Mr. N. W. Perry, in the *Trans. A.I.E.E.*, 1894, says, that the cost of producers or generators is about $11 per horse-power, which is less than that of steam boilers. He also gives an estimate by Dawson on a plant to have an output of 400 kilowatts, occupying a floor space 27 x 54 feet on one level and costing complete, about $10.38 per horse-power. He also says that gas can be transmitted a distance of 1 mile for a 3,000 horse-power plant with a loss of only 1 horse-power. Gantt, in *Cassier's*

Mag., vol. IX, p. 47, says, that a producer plant less than 1,000 horse-power costs more than a boiler plant, but for larger sizes it is more economical. Kerr, in *Cassier's Mag.*, 18–425, says that the first cost of gas-engine is greater than that of the same size of steam-engine, but the cost of complete plant is about the same. In *London Engineering*, January 4, 1901, is given an estimate on the cost of a plant to develop 2,000 electrical horse-power, using Mond gas with a plant to recover some of the waste products of the gas. The producer and recovery plant was estimated at about $64 per horse-power, which would make the plant compare very well with a steam plant as far as first cost goes.

It may be assumed that, in the average case, the first cost of a gas-engine plant is about the same as that of a steam plant of the same size and capacity, and that it will occupy much less space, besides being much safer in its operation than a boiler plant. It also requires but a small amount of water to run it, and if water is scarce, the same water may be used continually if arrangements are provided for cooling and circulating it through the jackets. A producer plant will need much less attention than a boiler plant, for the modern makes of producers are fed automatically, and they can be run for a short time and the gas stored for future use, although it is better to generate the gas only as fast as needed.

The use of the producer with gas engines is coming into extensive use, especially since the development of the engine in the last few years. The best-known form of producer on the market in this country is the Taylor, which is made in sizes down to 2 feet in diameter, this being large enough to supply a 30 horse-power engine. Any kind of coal may be used in this producer, anthracite being the better, and the gas may be used directly from the producer or it may be passed into a storage tank. The gas is usually cleansed before being used in order to take out the dust and other impurities that would tend to hinder the operation of the engine, although engines have been run direct from the producer. In Europe, they use the gases from blast-furnaces without washing at all and claim that the engines work satisfactorily.

Using coal in a producer in this way, a horse-power hour can be produced for a pound of coal even in the smaller sizes of engine, and this is so much better than the steam-boiler and engine can do, that it will certainly lead to their more extensive use, especially in cases involving only a small amount of power.

ELECTRIC POWER.

After having considered the prime sources of power in the preceding pages, the next thing to deal with is, naturally, the principal secondary source, which is electricity, and it will therefore be briefly treated in the following pages.

Electrical power is of comparatively recent date and was not used to any great extent until 1880, and it may be said that the last decade of the nineteenth century was the one in which the greatest development in this line occurred. The improvements in alternating current machinery and the use of polyphase currents of high potential for the long-distance transmission of power, together with the introduction of the rotary converter and the induction motor have caused phenomenal advances to be made in the use of this kind of power, especially for traction and lighting.

The great advantages of electricity over the other kinds of secondary power are, the ease with which it can be transmitted over long distances with losses in proportion to the amount of power that is so conveyed, its safety, cleanliness, ease with which it can be regulated and controlled, the absence of noise, dust and other objectionable features that are common to most of the other kinds of power, the high efficiencies of most of the electrical machinery, so that there is a smaller loss of power from the prime mover to the point of application of the power, and the adaptability of the electric current to so many uses. It has scarcely any real disadvantages, the principal one being that it is dangerous to handle and have in places where there is liability of fire being caused by its presence. The latter reason is groundless if the wiring is properly done, and the former is also of small moment, as but little high-tension current is installed

where there is liability of its being touched by persons who are not used to handling it.

The following table gives some figures on the cost of generating electric power. The costs are based upon the kilowatt-hour, which is the practical unit used to designate power, it being equal to 1·34 horse-power-hours. The cost is based, in most cases, upon the power delivered to the feeders that carry the current to the point of application. The cost for lighting and for power is usually different, as the power used for motors does not need such careful regulation of the pressure, and again the amount is usually large as compared with the amount sold for lighting, so that the cost to produce is less per unit and the amount is not so variable, hence the machines can be run at better efficiency.

The cost also depends upon the load factor of the plant; that is, upon the ratio of the average to the maximum output of the station, and the cost increases as this factor decreases.

COST OF ELECTRIC POWER.

Place and Use.	Cost K. W. Hour, Cts.	Authority.
Cheltenham, Eng., lighting	5.06	Lond., *E. Rev.*, Jan. 4, 1901.
Dundee, " "	4.90	" " "
London, price sold, "	5.00	" *E. Eng.*, "
" " " motors	5.00	" " "
Estimate operating expense	.58	Humphrey, *Lond. Eng.*, Jan. 4, 1901.
Lighting, .5 load factor	1.02	
Mfg. works, large	.92	
" " fairly constant	1.23	
" " small, "	2.60	
Ord. " varying load	1.92	
Small " " "	3.60	
Dudley, Eng., selling price	4.00	*E. W.*, Feb. 2, 1901, for tramways.
" " " "	10.00	Other uses.
Average for United Kingdom	5.34	Garcke, *E. W.*, Jan. 26, 1901.
American, practice, range 3.00 to	7.5	Bolton, A.S.M.E., 20–873.
Met. El. Ry., Chicago, op. expenses,	.88	*E. R.*, Feb. 15, 1901.
Glasgow, Scotland, " "	2.56	B.I.E.E.
Lighting, to get to customer	3.56	Field, *Cass. Mag.*, Mar., 1896.
Railway, operating expenses	.90	
" large, at bus-bars	1.00	Kennelly, *Cass. Mag.*, 13–531.
" " op. expenses	.50	
Niagara power in Buffalo	2·00	

Place and Use.	Cost K. W. Hours, Cts.	Authority.
Railway, estimated, 33 per cent. L. F.,	1.00	Conant, *S. R. J.*, 14-621.
Kansas City, op. expenses	.40	" " 14-71.
Average at board	8.00	Editorial, " 14-92.
Brooklyn Heights, op. exp.	.62	
Denver Ry.	1.10	*E. W.*, Feb. 26, 1901.
" motor work	4.00	
Kansas City, Ry. op. exp., 1899	.43	*W. E.*, Oct. 20, 1900.
" " " " 1900	.41	
Met. St. Ry., New York, 1898	1.57	*St. Ry. Jour.*, Nov., 1898.
Estimate at bus bars	.50	Bell, " El. Trans. of Power."

From the above table it may be seen that the cost of generating power is extremely variable in the different cases, depending upon the purpose for which it is used, the load-factor, the cost of fuel and the size of plant. For the case of large plants run by compound-condensing engines, with generators directly connected, operating under fairly good load-factors, it may be assumed that the cost of power per kilowatt at the bus-bars is not far from 1 cent, and it may be less with careful attendance. For water-power plants this figure may be lowered. The cost of distribution is so variable that no attempt has been made to estimate it, and it can only be approximated for specific cases.

The cost of electrical machinery depends upon the price of steel and copper to a large extent and so is variable, but may be assumed to range from $15 to $25 per kilowatt output for generators, motors or rotaries of the medium or large sizes. The price per unit increases as the size decreases, as they are less efficient and require more material and more labor in manufacture.

EFFICIENCY.

The efficiencies of electrical apparatus are usually very good, and range somewhere near the values given in the table below, which is for units of 100 horse-power or over, and applies to either direct or alternating current machinery.

	Per Cent.
Generators	90 to 96
Transformers	95 " 97
Transmission line	90 " 95
Rotaries	80 " 95
Motors	85 " 95

The above table is a fairly conservative one for this kind of machinery. For smaller units these values are too high, and in some cases of large machines operating under very good conditions they may be too low. The efficiency of transformers and synchronous motors with good power factors is very high and represents the limit of commercial machines.

The use of the storage battery is a great aid, in some cases, toward raising the efficiency of a power plant, for it allows the machines to be worked at their maximum efficiency and also relieves the prime mover from sudden variations of the load. This is especially noticeable in railway plants where the change of load is apt to be sudden, and also from a very small one to a very large one. Their use may take the place of an extra unit, which would only be used at the time of heavy load. The disadvantages of the storage battery are its high first cost, large repair and depreciation bills that come from its use, the extra amount of space they occupy, the extra cost involved in the purchase of a booster to be used in connection with them, so that they may be charged or discharged when the line pressure is different from that of the battery. Consequently, all things being considered, it is a question whether they are a paying investment.

The costs vary with the rate of discharge. If a battery has capacity enough to furnish 1,000 ampere-hours in one hour, and costs $80, then a battery to furnish the same number of ampere-hours at a discharge-rate of eight hours would cost $40. The cost is usually based upon a one-hour rate of discharge, and on the average may be assumed to be about $80 per kilowatt. This price includes switchboards and regulating devices.

LIGHTING.

The principal purposes for which electric power is used are lighting, traction, transmission, and power for driving shafting, or for other purposes where the steam-engine or other prime mover might be used. The subject of lighting will be treated first in respect to the relative efficiencies of

the different kinds of light, and then more especially in regard to the application of electricity.

Mr. J. Henderson, in an article in *Cassier's Magazine* for 1900, p. 336, gives a table of the commercial efficiencies of the various kinds of light; the commercial efficiency is that which is referred back to the coal, assuming that 1 pound of coal contains 11,000,000 feet pounds of energy and can yield about 4 cubic feet of gas at the lamp, representing 2,000,000 feet pounds of energy or an efficiency of 18 per cent., and in the case of the electric light, assuming the combined efficiency of boiler, engine and dynamo as 10 per cent., then the commercial efficiency of the lamps is as follows:

	Per Cent.
Bat's-wing burner	·23
Argand	·43
Incandescent lamp	·50
Arc lamp	1·30
Welsbach mantel	2·30

The luminous efficiency or the ratio of the light energy to the total energy radiated is given in the following table:

Source.	Efficiency. Per Cent.
Candle, ordinary wax	1·5
Bat's-wing gas burner	1·3
Oil lamp	2·0
Argand gas burner	2·4
Incandescent electric lamp	5·0
Lime light	9 to 14
Welsbach gas burner	13·0
Arc lamp	13·0
Magnesium ribbon	13·0
Electrical discharge in vacua	33·0
Sunlight	34·0

The efficiency of an electric lamp is usually stated at a certain number of watts per candle power. The ordinary arc lamp is more efficient than the incandescent. Some values given by Louis Bell, in his series of articles in the *Electrical World* for 1900–1901 for arc lamps, are: Arcs using clear outer globes and direct current, 2·89 watts per candle; similar alternating current arcs, 2·96 watts per candle; direct open-arc, 1 watt per mean spherical candle, and 1·3

for the same when shaded, while the same kind of lamps, using alternating current, required 1·7 and 2·2 watts per candle, respectively.

The following table gives some values of the power used for incandescent, arc and Nernst lamps gathered from various sources:

Authority	Watts per Candle. Inc'd.	Arc.	Nernst.
Elect. World, Feb, 9, 1901	3·1–3·5		1·6–2·0
" " 31–811, hor. c. p.	3·25	3·45 d. c.	
" " " mean spherical . .	4·00	3·54 a. c.	
Wait, H. H., 450 watt, mean hor. c. p.		·80 d. c. 1·20 " enclosed. 1·60 a. c. "	
A.I.E.E., 14–425, two clear glass globes .		·50	
" " open inner, clear outer .		·58	
" " both opal		·95	
Nernst, Dg., *E. W.*, 37–609, direct cur. .		1·37	1·90
Bell, *E. W.*, Jan. 26, 1901			1·62

COST OF LIGHTING.

Authority.	Cost in Cents per C. P. Hour. Electric. Arc.	Inc'd.	Gas. Ord.	Welsbach.	Acetylene
E. W., 37–246	·053	·053 ·041			
Guy, *El. Light and Power* .	·013	·056	·026		
Prog. Age, Dec. 1, 1897 . .		·063	·039		
E. W., 29–523		·063	·031	·011	·004
" 30–672		·041	·055		
" 31–670	·006	·039	·044	·011	·031
Eng. Mag., 4–241		·200	·162		
Jacobus, *J. F. I.*, 97–364. . .	·063	·061	·011	·011	·031

From the above tables it may be seen that the electric light is not the cheapest, the Welsbach burner and the acetylene light being much cheaper, while the ordinary bat's-wing burner is a close competitor with the incandescent lamp. The arc lamp is considerably cheaper than the incandescent, but is not used to any very great extent for the lighting of residences, etc., as it is not made in very small sizes, but it is being used more and more at the present time since the introduction of the enclosed forms of direct and alternating current lamps.

The great advantages of the electric lamps over the others lie in the fact that they do not vitiate the air of the

rooms which they light, and also give a light of such a color that it is not tiring to the eyes. It is very easily controlled, and by the use of the regulating or dimming sockets that are coming into use may be turned down in the same way that gas or acetylene is, so that a less amount of light and consequently, of power consumed, may be used as needed.

The Welsbach burner and the acetylene light both have the same disadvantage of producing a light that is very white and tiring to the eyes, while the incandescent lamp gives a light more the color of sunlight.

The use of alternating current lighting is perhaps the most common at the present time, although the Edison three-wire system is extensively used in the large cities where the population is dense and the line loss would not be excessive. The employment of high pressures on the line and the use of transformers to step down the voltage to such values that it can be safely used in houses is the general system at the present time. The alternating current can also be transmitted for long distances with but little loss, which is an important factor in a great many cases.

On account of the above facts, it is very doubtful if any other source of light will be developed that will supersede it for general use.

TRACTION.

The subject of traction is a very important one at the present time, especially in the large cities and in the suburban districts lying near them. For the power, in these cases, there are several kinds that may be used—electricity, steam, cable, compressed air or animal power. Of these, perhaps, the one most used at the present time is electricity.

The subject of electrical traction will be treated first, as it is the most important, and the following table may serve to show how much power is required by street cars. These are the results obtained by tests, and are expressed in kilowatt hours per car mile:

STREET-CAR TESTS.

Road, Equipment.	K. W. Hours per Car Mile.	Authority.
Met. Elev., Chicago, Sprague system	1·32	Gerry, A.I.E.E., 14-353.
" " " 4 car train	1·36	
" " " " "	1·32	
" " " 3 " "	1·69	
" " " 3 " "	1·62	
" " " 2 " "	1·58	
" " " 2 " "	1·76	
" " " 4 " "	1·11	
Lake St. "L," Chicago, G. E. No. 55 motor, 3 car train with 4 motors per car,	1·46	Chapman, *S. R. J.*, Oct., 1899.
Lake St. "L," Chicago, G. E. No. 51 B,	1·65	
Camden, N. J., 2 No. 38B mo., 50 H. P.,	1·97	*St. Ry. Jour.*, Nov., 1900.
" 2 No. 3 West. 30 "	1·47	
" 2 No. 5 Walker " "	·78	
" 1 No. 3 West. " "	1·00	
" 2 No. 49 35 "	1·26	
" 2 No. 33 West. 30 "	·79	

From the above table it may be seen that for the average case about 1·5 kilowatt hours per car mile are required for traction under the average city conditions. This is dependent upon the number of stops, the grades that have to be overcome, the efficiency of the motors, and also upon the way in which the motorman handles his controller and the speed that has to be made.

The cost of traction by different kinds of power is compared in the following table which gives the cost of operation per car mile of the various kinds. The column headed "Air" is for compressed air cars in which the air is held in tanks and then passed through reducing valves which reduce the pressure from about 2,000 pounds per square inch to about 150 pounds, after which it is reheated and passed through the motors which are similar to steam-engines in many respects. The electric cars are ordinary trolley or under-ground conduit system and the cable cars are the usual form of cable.

OPERATING EXPENSES OF STREET-CARS.

Authority, Remarks.	Operating Expenses, Cts. per C. M. Air.	Horse.	Cable.	Elect.
S. R. J., 14-65, Godfernaux			13.50	10.00
Jour. F. Inst., June, 1899			12.00	

Authority, Remarks.	Operating Expenses, Cts. per C. M. Air.	Horse.	Cable.	Elect.
S. R. J., 14–104, Chicago City, '97		24.10	10.71	13.05
" 15–580 " " '98		27.20	10.80	12.90
" " Met. St. Ry., N. Y. '98		11.96	18.00	11.95
" Oct., 1898, Conant (estimate)				9.50
" 15–51, 10 Mass. Report Com., 1900				16.10
Report Conn. R. R. Com., 1898				12.71
" N. Y. R. R. Com., 1900, av. of 26 roads				11.90
S. R. J., 16–43, Met. St. Ry., 1900	17.42	18.98	17.76	13.16

From the above it may be seen that the operating expense is variable and depends upon so many factors that it is impossible to get an average value, but the range may be indicated by the above figures.

The efficiencies of the different kinds of power used in traction vary to a great extent. The average efficiency of the electrical system from the indicated power of the engine to the car axle may be assumed to be about 50 per cent. Mr. Martin in a paper before the A.I.E.E. 4–26, gives the efficiency of the cable system in Kansas City as 25 per cent., in Chicago as 18·5 per cent. and in San Francisco as 33 per cent. From these figures it may be seen that the electric system is much more efficient, but in some cases the cable is cheaper in operating expenses than the electric.

TRANSMISSION.

The subject of transmission of power is a very important one at the present time. For this purpose, the electric current has no competitors for long distances as high potential alternating currents may be used with but a small loss in transmission. There are, however, different means of transmitting power for shorter distances, that are being used at the present time more or less. These are hydraulic, in which water under high pressure is conveyed in pipes and used in water-motors of different models, usually some form of the tangential or impulse wheel, pneumatic in which air under pressure is carried in pipes and used in motors which are similar to steam-engines and the use of belting or ropes or cables. The latter has been almost universally used in shops and factories where a large number of small machines were to be driven and for transmission from one building

to another. The use of compressed air has been used for air drills and for small power units, especially in contracting work and in mines where the exhaust air is needed for ventilating purposes. The hydraulic system is not used to any very great extent in the United States, but is used in London, in which city there is quite a large business. The electrical system is coming rapidly into use in factories and shops, either being used with motors directly connected to the different machines or a part of the shafting being driven by larger motors. The great advantage of this system is, that the loss is proportional to the load, while the loss by belting or shafting is constant, and although it may be small in proportion to the total power at full load, yet it is the same at light load, and is then much larger as compared to the load, and the efficiency is consequently lessened.

The following figures have been collected to show the relative efficiencies of the different methods of transmission for comparatively short distances. This table is from *Trans. A.I.E.E.* 18–412, computed by Wm. Geipel, of Edinburgh, and shows the first cost of plants per horse-power transmitted.

System.	Distance Transmitted, Yards.			
	100	1,100	11,000	22,000
Electrical	$155	$170	$286	$423
Hydraulic	68	186	800	1,510
Pneumatic	126	165	530	935
Wire rope	5	41	393	787

These values are proportional to the fixed charges.

The following table gives the relative efficiencies from input to output of the various methods and may be taken as representing average cases.

EFFICIENCIES.

Authority, Remarks.	Efficiency, Per Cent.			
	El.	Hyd.	Pneu.	Rope
Bell, "El. Transmission of Power," full load, high press. water, air not reheated	73	53	66	56
Bell, low press. water, air reheated		50	65	
" half load, same as first	65	45	40	46
" " " " second		50	50	
West. Electrician, Oct., 27, 1900	74			
Unwin, *Cassier's Mag.*, 1–449, air cold		40–50		
" " " " reheated		59–73		

Authority, Remarks.		Efficiency, Per Cent. El.	Hyd.	Pneu.	Rope.
Unwin, Same, 20,000 H. P., 20 miles, 133 lbs. press.					88 (estimate)
Telluride, Col., 120 H. P., 2·75 miles		75			
Pomona, Cal., A. I. E. E., 12-403, 42·5 miles		63			
Bell, *Eng. Mag.*, Jan., 1901, 1,000 H. P.		70			50
Adams, " 18-837		73			
Beringer, *Cass. Mag.*, 1-449, estimated	.5 mi.		50	55	91
	1 "		49	54	85
	3 "		41	51	61
	5 "		37	50	43
	10 "		26	43	21
	15 "		18	39	11

The above table may serve to show the difference in the relative efficiencies of the different methods. The highest is for electrical transmission, except for short distances, in which case the rope or belt-drive has the advantage, but its efficiency falls off rapidly as the distance increases. The electric system may be made very efficient by using high pressures and by putting in sufficient copper in the line to prevent loss due to the resistance of the conductor. There is a point where the fixed charges due to increase of copper overbalance the saving caused by such extra copper. If it is safe to assume that the efficiency of an electrical line can be made 90 per cent., and if the motors and generators are 85 per cent., then the total efficiency is 65 per cent. from the input of the generator to the output of the motor. The compressed-air system is very good in so far as the losses in transmission are concerned, but the principal losses are those in the motors, especially if the air is not reheated before being used in them.

Mr. Kennedy, in an article in the *Eng. Mag.* 3-585, says that a plant in Paris has an efficiency of 50 per cent. from the indicated horse-power of the compressor to the indicated horse-power of the motor when the air is reheated, the distance being four miles. Professor Saunders, in the *Journal of the Franklin Institute*, May, 1862, says, that for common machinery and no reheating the efficiency is about 30 per cent., best compressor and no reheating 40 per cent., and for the best machinery and reheated air the efficiency may be as high as 80 per cent.

In this connection, the use of electricity in shops and factories, in the place of belts and shafting, may be treated. As has been mentioned before, the loss in the electrical system is nearly proportional to the load, while the loss by belts and shafting is constant for all loads. The following table may serve to show the efficiencies that may be expected of shafting and belts:

Authority, Remarks.	Efficiency Per Cent.
Henthorn, A.S.M.E., 16-462, average practice	50-55
" " " 50 cotton or woolen mills	74
Barrus, " " 8 mills	78
Lufkin, *Cass. Mag.*, 5-369, av. of 30 tests in 1890	32
Benjamin, " 17-215, machine shops, average	45
Flather, *Eng. Mag.*, 8-670, average of 9 shops	60
Scott, "El. Power in Workshops," av. 319 French shops	60
Hutton, *Eng. Mag.*, Jan., 1901	60-80
Bell, " " wood and metal working	50-80
Lond. *El. Review*, Jan. 11, 1901, heavy machine work	55
" " " 8 factories in U. S. A.	56
Benjamin, A.S.M.E., 18-230, 3 cases, full load	56
" " " 6 " half "	45

These values are for the ratio of power taken from the shaft of the machines to that put into the main-line shaft at the engine and includes only the loss in belts and shafts.

The losses in the electric system are less than in the other. The following table may serve to show what efficiency can be obtained by the use of motors directly connected to the machines:

Authority, Remarks.	Efficiency. Per Cent.
Elect. World, Feb. 16, 1901	73
Engineer (N. Y.) Jan. 1901, 300 H. P.	71
West. Elect., Mar. 16, 1901	62
Louis Bell, *Eng. Mag.*, Jan., 1901, not over 5 per cent. drop on 5 load	75-80
Lond. *El. Rev.*, Jan. 11, 1901	81
Richmond, *Eng. Mag.*, 8-669, ordinary cases	50
" " " more favorable conditions	73
Anthony, " " estimate, 1 to 5 H. P. motors	20

The above shows that a fair average efficiency is about 70 per cent. for good systems, and is about 10 per cent. or 15 per cent. higher than can be expected from shafting and belts.

The table below, taken from E. K. Scott's "Electric Power in Workshops," shows the relative efficiencies of the two systems for different loads, and is estimated, with all the losses taken into account, both mechanical and electrical. It is from the developed power of the engine to the power available at the machine, and is for a 1,000 horse-power engine. The constant loss in the belting and shafting is 200 horse-power for the case of the belt drive.

This table was calculated by M. Felix Mélotte. The table has a great many items that are omitted here, but the main ones are given below. All figures are in horse-power.

Horse-power, per, by engine	1,000	750	500	250	200
Constant friction loss	50	50	50	50	50
Variable elect. loss	50	27	11	4·5	1·2
Total loss in dynamo	100	77	61	52·2	51·2
Loss in conductors	18	10	4	·8	·5
Loss in motor	88	73	61·5	54·7	53·1
Power available at machine	794	590	373·5	142·3	94·5
Total efficiency, per cent.	79·4	87·7	74·7	57·0	47·2

SAME FOR MECHANICAL TRANSMISSION.

Loss in shafting and belts, constant at 200 horse-power.					
Power available at machine	794	544	294	44	0
Total efficiency, per cent.	79·4	72·5	58·8	38·1	0

From the above it may be seen that the two systems are about the same in efficiency for full load, but the falling off of efficiency for lighter loads is much more rapid in the case of the shafting. This is a very important item, especially for machine shops which have variable loads, and is not so much so for cotton mills or other factories that have constant loads.

THE SAND BLAST FOR CLEANSING STRUCTURAL IRON WORK.

The best means of protecting structural iron work, such as railway stations, bridges, escapes, due to the action of the elements and to the corrosive influences of the gases emitted from locomotives, have been earnestly sought by engineers, and there is yet much diversity of opinion among them on the subject. Thus far the only method pursued is that of systematically keeping the iron work of these and similar structures protected by repeated applications of paint, the material used for the purpose being either oxide of iron or red lead in linseed oil. The deterioration of these coatings, however, is so rapid that constant watchfulness is required to keep the metal beneath free

from rusting. The trouble arises partly from the gradual cracking of the paint film which allows the penetration of moisture and corrosive gases to the metal surface, causing the formation of rust and the lessening of the adherence of the paint, and partly to chemical changes in the paint film itself by the absorption of sulphurous gases. From these causes principally the frequent renewal of paint on exposed iron structures is found to be a necessity to preserve their integrity, and the nominal cost of this sort of work to the railroad companies is a very considerable item. Numerous investigations have been undertaken with the view of finding some substitute for the paints and oils usually employed for the purpose, or to secure their better adherence and greater durability, but thus far without substantial results.

The overhead iron work of one of the stations of the Manhattan Elevated Railroad in New York affords a conspicuous example of what has been stated. It was found that the metal of this structure is so strongly and rapidly corroded by the sulphurous gases of the locomotives that the yearly renewal of the paint with which it was coated was insufficient to preserve it. It was accordingly determined to make an exhaustive series of trials of the most approved paint compositions that could be found in the market. Some eighteen different compositions were applied to different portions of the structure, and their effects as protective coverings are to be closely observed.

The specially interesting feature of these trials, however, is the fact that the sand-blast was used for the purpose of removing the old paint and thoroughly scouring the metal before applying the new coatings. The object of this preliminary treatment was to obtain a clean metallic surface, to which the paint would adhere as perfectly as possible. The result of this operation has thus far not been made public. W.

PIVOTED OR SWINGING WINDOWS.

The city of Chicago has enacted a building ordinance requiring that on all new buildings there shall be swinging windows above the second story. The object sought to be accomplished by this enactment is to prevent the accidents in washing windows which are of common occurrence.

The ordinance specifies that the window must swing on four vertical or horizontal pivots, or otherwise a balcony must be built around every window. It is said that the local architects and builders object to the law. W.

ZINC BY ELECTROLYSIS.

Electrical Review is responsible for the statement that the extraction of zinc from its ores by electrolytic methods has been attempted at Hayle, in Cornwall, and at Milton, in Staffordshire. At the first-named place a leaching process, patented by Cowper-Coles, was operated with indifferent results, and the experimental plant is now shut down. At Milton the Swinburne-Ashcroft fusion process has been under trial by the Phœnix Process Syndicate with fairly satisfactory results. The inventors believe that with slight modifications this process will solve the problem of winning all the metals contained in the mixed sulphide ores.

The experimental trials of this process have been transferred to Weston Point, and the Milton works have now been dismantled. W.

Mining and Metallurgical Section.

Stated Meeting held April 10, 1901.

THE INSPECTION AND TESTING OF CEMENTS.

BY RICHARD L. HUMPHREY,
Member of the Institute.

The subject upon which I shall claim your attention this evening may be comparatively new to some, familiar to many, and a very old, old story to others.

After nearly ten years' experience in the inspection and testing of cements, I feel that I am in a measure qualified to speak on the subject, and if I am able so to present the matter as to enlighten any in this audience, I shall feel that the effort has been justified.

The testing of cements has been engaging the attention of engineers and cement manufacturers for many years, and as yet no entirely satisfactory system has been proposed which will eliminate the personal equation of those who make the tests, a variation which renders the results of such tests not only relative but inaccurate.

The endeavor to secure methods or appliances by which the personal equation is reduced to a minimum is of paramount importance to those upon whom devolves the task of making the tests, which determine the value of cements for constructive purposes.

The inspecting and testing of cements is an art requiring much skill and considerable experience. Of the materials of construction, cement is one of the most difficult to test, and to interpret the results obtained.

From the moment the clinker is reduced to an impalpable powder, its physical and chemical properties are constantly undergoing changes which affect its quality and value as a building material.

Even after the cement has been made into a mortar and become a part of the structure, these changes continue, being to a greater or less extent effected by external influ-

ences tending to decompose the mortar, or by internal influences tending either to disintegrate the mass or accelerate the process of crystallization usually known as hardening. Indeed, it is probably true that these influences never cease. The strength and quality of the material during this period is an unknown factor, and our knowledge as to the exact nature of these changes is purely theoretical. Much research will be required in order to be able to state just what these changes are.

The ancient Romans and others had learned by experience that mixtures of fat lime and volcanic ash when made into a mortar upon the addition of water, possessed the property of hardening and acquiring some strength, and were, therefore, adapted for building purposes.

It was at first thought that the strength of the mortar was dependent on the absorption of carbonic-acid gas from the air, which, reacting on the lime, formed a hard carbonate. Later researches have shown, however, that only the outer surface was converted into carbonate of lime, and that this carbonization after many years did not extend more than one-eighth of an inch below the surface of the mortar.

Another theory advanced was, that the volcanic ash contained silica in a soluble form which reacted on the hydrate of lime to form a silicate of lime. It has been shown that only the outer surface of each grain of silica has been converted into silicate of lime.

It is probably true that the lime, upon the addition of water, was converted into a hydrate, and that the formation of carbonate of lime, by the absorption of carbonic-acid gas from the air, acted as a protection against the action of rains and other forces of nature tending to dissolve and wash out the hydrate of lime.

Lime mortar and mixtures of slacked lime and puzzolanas or trass continued to be the building material until the close of the eighteenth century.

This material made a very poor mortar and numerous experiments were made to discover something more durable.

Dr. Higgins, an English writer, in reporting the results of his experiments on calcareous cements and quicklime, published about 1780, complains that the "strength and duration" of their most "useful and expensive buildings depends on the goodness of the mortar, which is commonly so bad that the timbers of the buildings last longer than the walls unless the mouldering cement be frequently replaced by pointing."

The object of his experiment was to "recover or to excel the Roman cement which had withstood every trial of 1,500 or 2,000 years."

In 1756, Smeaton, in rebuilding the Eddystone Lighthouse, experimented with various limestones and mixtures of slacked lime, dutch trass and puzzolanas, in his endeavor to find a material that would harden under water. He finally found that a mixture of slacked lime and puzzolanas attained the greatest hardness under water.

Parker, in 1795, took out a patent for a water cement, and, in 1824, John Aspdin, a Leeds bricklayer, took out letters patent for a material which he called "Portland Cement," on account of its resemblance to the building stone coming from the Isle of Portland off the coast of England.

Prior to this period the endeavor was to equal or excel the Roman cement, which was produced by grinding calcined septaria nodules. This cement corresponded to a class of natural cements in this country, commonly known as "Rosendale," "Lehigh," "Cumberland," "Louisville" "Utica," etc. The development of the cement industry began shortly after the granting of the patent of Aspdin, starting in England and spreading gradually into France, Germany and other European countries. Natural cement was first made in this country in 1818 by Canvass White, and was used largely in the construction of the Erie Canal.

It is noticeable that nearly all the early natural cement factories were located along the banks of canals and that the product of these factories was used in their construction. Thus we find that the cement made at Rosendale, Ulster County, N. Y., was used in the construction of the

Delaware and Hudson Canal; the cement manufactured at Louisville, Ky., in the Louisville and Portland Canal; that made at Round Top, Md., in the Chesapeake and Ohio Canal; the Illinois and Michigan Canal was built with cement made at Utica, Ill.; while the cement made at Siegfried's Bridge, Pa., was used in the Lehigh Coal and Navigation Company's Canal.

The total production of natural cement up to 1830 amounted to 300,000 barrels; since then it has grown steadily until in 1900 it amounted to over 10,000,000 barrels.

In this country, since 1890, the development has been principally in the manufacture of Portland Cement. The production increasing from 400,000 barrels per annum in 1890, to over 8,000,000 barrels per annum in 1900.

DEVELOPMENT OF METHODS.

Smeaton, in order to determine the value of his various cements, made them into balls and immersed them in water, thus establishing their hydraulic qualities.

Vicat, in his celebrated book, entitled "Experimental Researches on the Limes of Construction, Concretes and Ordinary Mortars," in order to determine the relative value of mortars, devised an apparatus which bears his name, and which has been modified, and is now used in determining the time of setting. Vicat's test was to allow a needle loaded with a given weight to fall a given distance into the mortar. The amount of this penetration was measured; the amount of penetration being proportional to the hardness. (Plate I.)

Prior to the experiments of Colonel C. W. Pasley, in 1830, a common method for testing the cementitious value of limes and cement, was to stick bricks together with it, one at a time, projecting horizontally from a wall. That lime or cement was considered the strongest which held the greatest number of bricks. In this test no distinction was made between quick and slow setting cements. (Plate II, *Fig. 1.*)

A similar practice was in vogue in the city of Philadelphia for a number of years. Inspectors on the work satis-

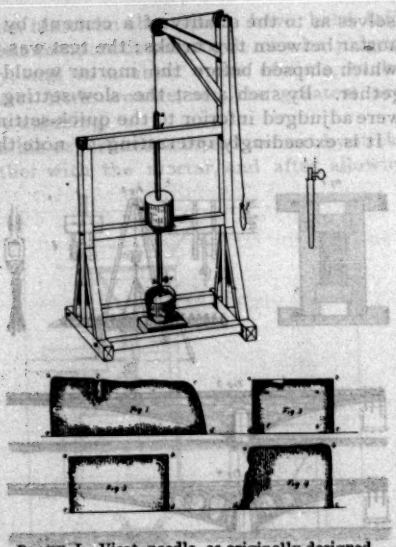


PLATE I—Vicat needle, as originally designed.

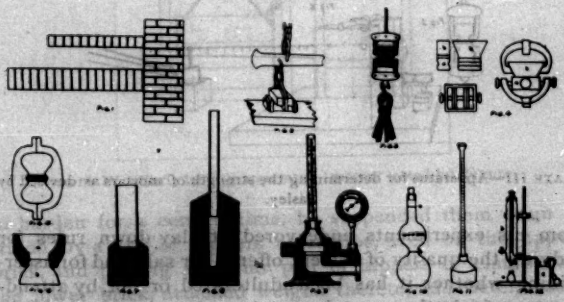


PLATE II—Figs. 1 to 6, adhesive tests; figs. 7 to 9, porosity tests; fig. 10, Keate's specific gravity flask; fig. 11, Schumann's volumenometer; fig. 12, Erdmenger volumenometer.

fied themselves as to the quality of a cement by placing a layer of mortar between two bricks; the test was to observe the time which elapsed before the mortar would hold the bricks together. By such a test the slow-setting Portland cements were adjudged inferior to the quick-setting natural cements. It is exceedingly interesting to note that Pasley

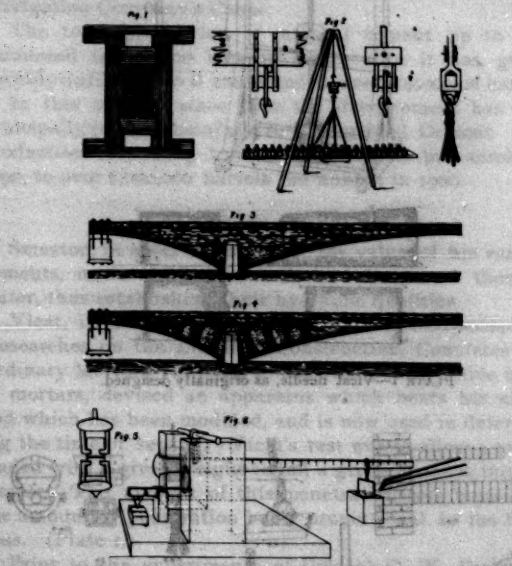


PLATE III—Apparatus for determining the strength of mortars as devised by Pasley.

from his experiments endeavored "to lay down rules for judging the quality of cement offered for sale and for ascertaining whether it has been adulterated or not, by attending to which the most inexperienced person may easily detect such frauds in twenty-four hours, or less." In view of our present difficulties and troubles in securing uniformly

accurate tests, his claim that "rules have been laid down, by which their comparative strength may be judged of experimentally, and in a short space of time, such as ten days, with very little trouble, and the greatest accuracy," appears very amusing.

Pasley, in his experiments, tested cement by sticking two bricks together with the mortar, and after allowing them

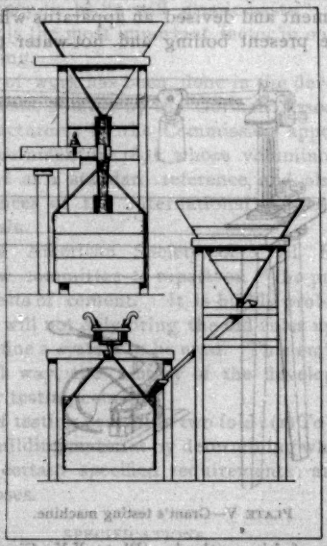


PLATE IV—Early testing apparatus—mortar tested by flexure.

to harden for a certain time, he suspended them from a tripod, by a pair of nippers or clamps, fixed on the upper brick, and placing a similar pair of nippers or clamps on the lower brick, attached weighs thereto, and determined the weight required to pull the bricks apart. He also ascertained the time required for the cement to harden under water. (See Plate III.)

In 1858, John Grant, engineer for the Metropolitan Board of Works, in connection with the London Drainage Works, began his well-known tests of cement. He was the first to develop definite methods for testing cement. He devised a machine for determining the tensile strength of cement after which the present Olsen and Riehlé machines are patterned. (Plate V.)

Later, Henry Faija showed the importance of the soundness of a cement and devised an apparatus which bears his name. The present boiling and hot-water tests are but

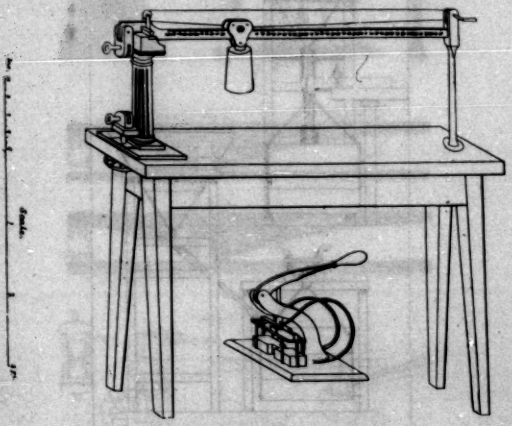


PLATE V—Grant's testing machine.

modifications of his method. (Plate XX, *Fig. 1.*) He also devised a short-lever machine for determining the tensile strength. Michaelis also devised a similar machine to which the Fairbanks machine owes its origin. It is interesting to note that Faija did not believe in the utility of the sand test, maintaining that it first involved testing the sand and was, therefore, valueless as a comparative test unless the same quality of sand could also be guaranteed. (Plates XIII and XIV.)

The development of the methods of testing came slowly after Grant had set the pace, and Faija and Michaelis had improved and added to them. The Committee of the American Society of Civil Engineers, in 1885, formulated the rules which have been in vogue in this country, and have been generally accepted as the standard. These rules have well served their purpose, but are now, however, deficient in many respects, notably in that which defines the normal consistency to be "a stiff plastic paste." The normal consistency is the most important factor in our present methods of testing.

A great deal of work has been done in the development of methods of tests, notably by the German Association of Cement Manufacturers; by the Commission appointed by the French Government in 1891, whose voluminous report may be regarded as a standard reference, and also by the various conferences of the International Association for Testing Materials.

In 1899, the American Society of Civil Engineers appointed a new committee to report on "the proper manipulation of tests of cement." It is highly probable that this committee will not only bring the old rules up to date, but will also define a system to be used. This embraces, in a brief, general way, the history of the development of the methods for testing cement.

The object of testing cement is two-fold: (1) To ascertain its value as a building material by determining whether the cement meets certain specified requirements; and (2) for scientific purposes.

SPECIFICATIONS.

The first requisite in any system of inspection is a standard by which to gauge the quality of the material. This standard is usually established by each engineer to suit his conditions. In establishing this standard the engineer will save himself needless trouble by first selecting, wherever possible, some one who will make the tests and ascertain what tests he is able to secure from well known brands of cement, and then fix his requirements in accordance with

these results. As the cement inspector acquires greater skill in making the tests, and is, therefore, able to obtain higher results from cement, this standard can be raised. The present high standard of the city of Philadelphia is the gradual development from such a system.*

INSPECTING AND SAMPLING.

On account of the changes which take place in the quality of the cement, from the time it leaves the factory until it is delivered at the point of consumption, it is customary to inspect the cement on the work in which it is to be used; although it is true that in some important engineering works it has lately been the practice to inspect the cement at the place of manufacture. Each shipment of accepted cement is marked by the inspector.

This method avoids extra handling of the cement in case it is not up to the prescribed standard, since the inspector can select from the various bins at the factory the cement required. It is also the custom to make check tests upon the arrival of this cement at the place of consumption.

Cement is usually shipped in cotton sacks or paper bags, although about 25 per cent. of the shipments are in wood. Where cement is going to be used immediately and will not be held long in storage, the bag shipments are undoubtedly more convenient and satisfactory, besides being more easily handled on the work. Such shipments can also be sampled much more thoroughly. Cement was shipped in barrels in this country in the early days, as it was generally accepted that cement must be kept in tight packages, as it deteriorated in the air; and besides nearly all the early natural-cement mills were located along canals, and the cement had to be placed in wooden packages for water shipments. Again, prior to 1893, foreign Portland cement was used very extensively in this country, and on account of the ocean voyage it was absolutely necessary to pack the cement in tight, well-coopered barrels in order to avoid damage to the cement from sea-water, and to the barrel from the handling

* *Jour. Franklin Institute*, Vol. CXLVI, No. 5, p. 344.

it received in loading and unloading. When the American cements began to replace the foreign Portland cements the American engineers had become so accustomed to cement in barrels that they continued to insist on shipments of cement being delivered in wood. This sentiment is, however, undergoing a change, and bag shipments are becoming the rule. Another advantage of having cement delivered in sacks is the reduced cost of the package.

The danger of inferior cement being rebagged is readily avoided by requiring the cement manufacturer to seal his bags with a lead seal, such as is the custom in France and other foreign countries. The packages should state plainly the brand, name and place of manufacture, and all shipments of cement which are not properly labelled should not be inspected.

Shipments of cement are usually made in carload lots of 100 barrels each, although in some cases a shipment will contain 150 barrels; it is convenient, therefore, to inspect cement in carload lots, particularly where there is a large amount of cement entering into the structure.

In selecting the sample for testing a note should be made of the general condition of the shipment; that is, whether the cement is caked, lumpy, or otherwise damaged, as, in many cases, owing to improper protection, the shipment is damaged pending the tests.

The test sample should be taken from the heart of each package, since the quality of the cement on the outer portion of the package is sometimes more or less impaired. The jarring the package receives in transportation over the railroad has a tendency to separate the coarse from the fine particles. Where the cement is delivered in barrels, the sample is drawn from the center by making a hole in the center of one of the staves, midway between the heads, and collecting this sample through the hole by means of a scoop. In bag shipments the sample can be extracted by means of the hand or a scoop. In barrel shipments a sample should be taken from one barrel in every ten; and in bag shipments a sample should be taken from one bag

in every twenty. About one-half pint should be taken from each package in barrel shipments, and about half this quantity in bag shipments. Well-established brands of cement should ordinarily be accepted on the results of the "seven days' tests."

In case of failure of the shipment to meet the seven-day requirements, it should be held to await the results of the twenty-eight day tests. Care should be taken to see that shipments of cement, while awaiting the result of the tests, are thoroughly protected from the weather; the cement should be well housed and carefully blocked from the ground. I have known instances where cement which met the requirements, through the lack of protection during the tests, had become so badly damaged as to render it unfit for use. Under such circumstances it would be unsafe to use the cement, and yet it would be a decided injustice to both manufacturer and contractor to hold the cement for a retest. Such complications could be avoided by insisting that the cement be properly housed and protected before inspecting it.

Where sampling cans are used, containing several compartments, care should be observed to mark each compartment so that the samples cannot be confused. It is best to number the compartment on the can, and make a record of the sample at the time of collection. (See Plate 6, *Fig. 10.*) The ten or twenty individual samples which comprise the general sample should be thoroughly mixed before attempting to make any tests. This is best accomplished by passing the sample through a coarse sieve, either a No. 20 or No. 30. This not only thoroughly mixes the sample, but also removes sticks, stones or other foreign matter.

The tests which should be made will depend on the importance of the work and the facilities for making them. The simplest methods, as a rule, yield the most uniform tests; and the uniformity of the tests is a matter of prime importance.

I am not in favor of any system which depends on cumbersome methods or expensive apparatus. The number of tests required should be few, and simple in execution.

Tests are made for the purpose of establishing the qualities of a cement—uniformity of composition and burning, fineness, soundness and strength.

CHEMICAL ANALYSIS.

Systematic chemical analyses of cement should be made in all permanent laboratories; not with a view of eventually introducing into specifications chemical requirements (other than those for sulphuric acid and possibly magnesia), but in order that we may have some data pertaining to the composition of the cement when studying the results of the long-time tests.

When, however, they are required on the work, the sample should be sent to a well-established chemical laboratory having proper facilities for accurate work, as such analyses should be made only by a skilled chemist.

I have used the following scheme of chemical analyses with excellent results:

One-half gram of the finely pulverized sample, dried at 100° C., is thoroughly mixed with four or five times its weight of sodium carbonate and fused in a platinum crucible until CO_2 no longer escapes; the crucible and its contents is placed in a beaker and twenty or thirty times its quantity of water, and about 10 cubic centimeters of dilute HCl is added; when complete solution is effected, it is transferred to a casserole, placed on a water bath, and evaporated to dryness several times. The mass is taken up with dilute HCl and water, heated for a short time and filtered, washing the residue on the filter thoroughly with hot water. The filter is dried, ignited and weighed. This weight (less ash) gives the amount SiO_2.

The filtrate is brought to boiling, and ammonia is added in slight excess; the boiling is continued until the odor of ammonia is no longer perceptible. Filter and wash re-dissolved in hot dilute HCl, again precipitate with ammonia and filter through the previous filter and wash with boiling water. The precipitate dried, ignited and weighed, less ash, gives the amount of Al_2O_3 and Fe_2O_3.

The iron is determined volumetrically by fusing the

ignited precipitates of alumina and iron with de-dydrated potassium sulphate in the platinum crucible; it is then dissolved in sulphuric acid and tirated with potassium permanganate.

The filtrate from the iron and alumina is heated to boiling, and boiling ammoniam oxalate is added until a precipitate is no longer formed. After boiling for a few minutes, it is set aside for a short time; when the precipitate has settled perfectly, decant the clear liquid through a filter, wash by decantation, dissolve the precipitate in hot dilute HCl, using as small a quantity as possible to effect a complete solution; heat to boiling and add ammonia, heat on a water bath for a few minutes; when the solution clears filter through the previous filter, wash thoroughly with hot water. Dry the precipitate, ignite to constant weight, and weigh as CaO; or determine the lime volumetrically by titration with potassium permanganate.

The thoroughly washed precipitate of calcium oxalate is dissolved in hot dilute sulphuric acid and the solution is titrated with potassium permanganate.

The filtrate from the calcium oxalate is made alkaline with ammonia and 30 cubic centimeters of solution of hydrodisodium phosphate is added; the whole is set aside in a cool place for twenty-four hours; it is then filtered and washed about fifteen times with ammonia-water solution (1 : 5). Dry the precipitate on the filter, brush on to a large watch glass, burn filter on the lid of the weighed crucible. When the carbon is consumed, transfer the precipitate to the crucible and ignite to dull redness, keeping the crucible covered. If the precipitate is not perfectly white on cooling, moisten with a few drops of nitric acid, evaporate and ignite to dryness; weigh as magnesium pyrophosphate and calculate to MgO.

Sulphuric acid. This is determined in a separate portion. Weigh out about five grams and treat as in the regular analysis, separating the silica; the filtrate is heated to boiling and boiling barium chloride is added; the boiling is continued for ten minutes; when the precipitate has subsided, filter. The precipitate is thoroughly washed in

hot water, dried, ignited and weighed as barium sulphate and calculated to So_3.

Carbonic acid. This can be determined with sufficient accuracy by means of the ordinary extraction apparatus.

FINENESS.

The fineness to which the cement has been ground is usually measured by the percentage of residue on what are known as No. 50, No. 100 and No. 200 sieves, having approximately 2,500, 10,000 and 40,000 meshes per square inch. As it is impossible to obtain sieves of exactly this number of meshes the sieves should be definitely described; *i. e.*, the size of wire and actual number of meshes per square inch should be stated. The No. 50 sieve can be readily obtained; the No. 100 much less readily, while it is impossible to obtain a standard No. 200 sieve. The meshes in the cloth vary from 30,000 to 46,000 meshes per square inch.

The No. 50 sieve has no practical value, since all cements of good quality leave practically no residue on this sieve.

The sample for sieving should be thoroughly dried at a temperature of about 130° F, since in this condition the cement sieves much more readily. One hundred grams make a very convenient quantity to sieve.

The manner in which the sieving is done determines to a large extent the time required for the operation. After the fine flour has passed through the sieve the coarser particles pass through very slowly; and, since the final operation determines the fineness, it is important that it should be done thoroughly. I have, after considerable experiment, decided that the operation of sieving was for all practical purposes complete when not more than $\frac{1}{10}$ of 1 per cent. passes through the sieve after five minutes' continuous sieving.

Various mechanical devices have been devised for automatic sieving, but as far as my experience goes there is none that has proved satisfactory. The apparatus which is used in the laboratory of the city of Philadelphia works fairly well on some cements; with others, however, it is im-

possible to sieve them. Sieving by hand is by far the best method; in this case the most effective way is to move the sieve backwards and forwards in a slightly inclined position, and striking the sieve sharply and continuously with the palm of the hand. The number of strokes per minute should be about 200. The cloth of the sieve should be carefully watched, as it is liable to break and thus become defective, giving rise to incorrect and abnormal tests. The size of the sieve also effects the rate of sieving. A sieve 8 inches in diameter is a good size. Large pebbles, gravel, sand or shot which are retained on a No. 10 sieve are often placed in the sieve with the cement. This tends to accelerate the operation of sieving, but it is exceedingly hard on the cloth of the sieve, and for this reason is objectionable.

The methods for determining the fineness by elutriation and by air separation have not been sufficiently tried to enable an opinion as to their merits to be formed.

The former does not seem, however, to be adaptable for quick work. The latter merits further investigation, and it is not improbable that it will eventually supersede the unsatisfactory method by sieves.

SPECIFIC GRAVITY.

The true density or specific gravity of cement is of considerable value when properly used. I do not recommend the test, except for a permanent laboratory, since it is a test requiring skill and accuracy, and is, therefore, not adapted as an ordinary test of reception on the work.

Where the tests can be properly made, it is of considerable value in detecting adulterations, etc. Quite a number of appliances have been devised for making this test, among which may be mentioned Le Chatelier, Candlot, Mann, Schumann and Erdmenger. Of these Le Chatelier's is unquestionably the best, since it is the most convenient to use and less liable to error from retained air bubbles and leakage at the connections, as in the other forms.

Le Chatelier's Apparatus.—This apparatus consists of a flask *D* (Plate VI, *Fig. 3*) of 120 cubic centimeters capacity, the neck of which is about 20 centimeters long. In the middle of this

neck is a bulb *C*, above and below which are two marks engraved on the neck, the volume between these marks, *E* and *F*, being exactly 20 cubic centimeters. Above the bulb the neck is graduated into $\frac{1}{10}$ cubic centimeters. The neck has a diameter of 9 millimeters. Benzine, being free from water, and being neither very volatile nor hygroscopic, is used in making the determinations.

The specific gravity can be determined in two ways; (1) The flask is filled with benzine to the lower mark *E*, and 64 grams of powder are weighed out; the powder is carefully introduced into the flask by the aid of the funnel *B*. The stem of this funnel descends into the neck of the flask to a point a short distance below the upper mark. The cement cannot stick to the sides of the neck and obstruct its passage. As the level of the benzine approaches the upper mark, the powder is introduced carefully and in small quantities at a time until the upper mark is reached. The difference between the weight of the cement remaining and the weight of the original quantity (64 grams) is the volume which has displaced 20 cubic centimeters.

(2) The whole quantity of cement is introduced, and the level of the benzine rises to some division of the graduated neck. This reading + 20 cubic centimeters is the volume displaced by 64 grams of cement. The specific gravity is then obtained from the formula:

$$\text{Sp. gr.} = \frac{\text{Weight in air.}}{\text{Displaced weight or loss of weight in water.}}$$

The flask, during the operation, is kept immersed in water in a jar *A*, in order to avoid any possible error due to variations in the temperature of the benzine. The cement in falling through the long tube completely frees itself from all air bubbles. The results obtained agree within .02.

TIME OF SETTING.

A common test, and one of much practical importance, is the time of setting together with the auxiliary test, rise in temperature of paste during setting. This latter test is, however, both valueless and dangerous, except in the hands

of an expert, under whose manipulation it will indicate imperfect composition and freshness in cements.

Vicat devised the original apparatus for determining the rate of hardening of lime mortars. In the tests as recommended by Vicat, the weighted needle was allowed to fall into the material under test. The tests as now used, the needle is applied carefully to the surface and allowed to sink into mass under a given weight. Gilmore's wires are commonly used, but as they are likely to be applied in an irregular manner at an acute angle, giving rise to great discrepancies in the results of the test, they are not as desirable. These wires (Plate VI, *Fig. 2*) are the one-quarter on a needle having $\frac{1}{12}$ of an inch area for the initial test, and 1 pound on a needle having $\frac{1}{24}$ of an inch area for hard set. An excellent modification is one in which an upper guide keeps the needle in a perpendicular position.

In Germany, the set is determined by noting the time which elapses before the cement will resist the firm pressure of the thumb-nail. Both the Gilmore wire test and thumb-nail test give misleading results, since they are made on the surface of the mass only. For this reason I prefer the Vicat needle apparatus, because the needle penetrates into the mass; and while it is true the final set is just as hard to determine, yet the "initial set" and the most important test is very readily determined. It is very difficult to decide the exact time the needle ceases to make an impression. In slow-setting cements different persons will vary greatly as to the determination of this point. In the Vicat apparatus the needle is applied perpendicularly. M. Bonnami modified the Vicat test by defining the initial set as the time elapsing before the needle under a load of 50 grams, sank into the mass half-way, and hard set as the time when it sank half-way under a load of 3,000 grams. I am of the opinion that the hard set should be defined as the time which elapses before the penetration of the needle ceased to pass a point just below the surface. The determination of the time of setting is only approximate, the results being materially effected by the temperature of the mixing water and of the air during the test, the humidity of the atmos-

phere, the percentage of water used and the amount of molding the paste receives.

As cement usually loses strength by retempering, it is necessary to have a general idea of how long it takes cement to set and thus provide against retempering of the mortar on the work. Set tests are made on neat cement pastes only, as in sand mortars the grains of sand impede the free penetration of the needle.

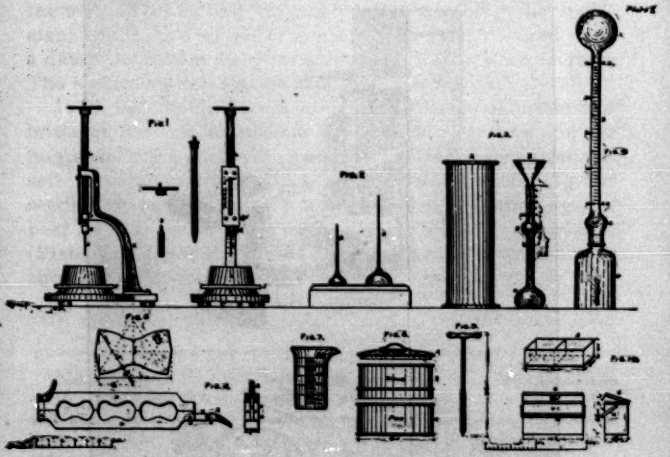


PLATE VI—Fig. 1, Vicat needle; fig. 2, Gilmore wires; fig. 3, Le Chatelier specific gravity apparatus; fig. 4, Candlot specific gravity apparatus; fig. 5, Am. Soc. C. E. briquette; fig. 6, gang mold; fig. 7, measuring glass; fig. 8, sieve; fig. 9, sampling iron; fig. 10, collection can.

The following is a description of the Vicat needle apparatus:

The Vicat needle, illustrated in *Fig. 1*, Plate VI, consists of a frame *K*, bearing the movable rod *L*, having the cap *D* at one end and the needle *H* having a circular cross-section of 1 square millimeter at the other. The screw *F* holds the needle in any desired position. The rod carries an indicator, which moves over a scale (graduated to centimeters)

borne by the frame *K*. The rod with the needle and cap weighs 300 grams; the paste is held by a conical hard rubber ring *I*, 7 centimeters in diameter at base, 4 centimeters high, resting on the glass plate *J*, 15 centimeters square.

For neat pastes the setting is said to have commenced when the polished steel needle, weighing 300 grams, does not completely traverse the mass of normal consistency confined

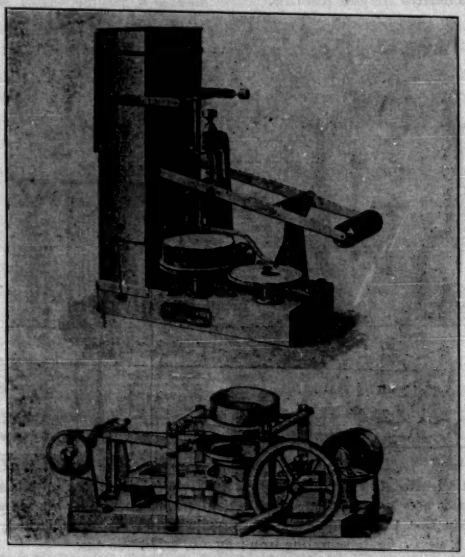


PLATE VII—Fig. 1, Amsler-Laffon "time of setting" machine; Fig. 2, Petmajer sieving apparatus.

in the rubber ring, and the setting is said to be terminated when the same needle gently applied to the upper surface of the mass does not sink visibly into it.

A thermometer *C* graduated to $\frac{1}{5}$° C. is stuck into the mass and the increase of temperature of mass during setting can be thus observed. The paste is kept in the moist closet

during the operation, being removed only to make trial tests of the setting.

Care should be taken to keep the sides of the needle clean, as the collection of cement on the needle retards the penetration of the needle, while cement on the point of the needle reduces the area of needle and tends to increase the penetration.

The test specimens should be kept in moist air during the test. This is best accomplished by placing the specimens on a rack over water contained in a pan covered with a damp cloth, kept away from the specimen by a wire screen The specimens can also be kept in a moist closet.

It is impossible to catch the exact time of either the initial or hard set unless one continuously observes the set ting, usually the trial test is made just before or just after the set. Several appliances have been devised for recording the setting automatically and autographically; probably the best is that made by Amsler and Laffon, of Switzerland. (Plate VII, *Fig. 1.*) There is also an automatic appliance in the cement laboratory of Cornell University.*

[*To be continued.*]

THE ELECTRO-METALLURGY OF ZINC.

Commenting on the highly interesting and suggestive presidential address of Mr. J. W. Swan, F.R.S., lately given to the Society of Chemical Industry, and which was devoted to an exhaustive review of the electro-chemical industry, the *Electro-Chemist* has the following to say as to his references to zinc:

"Foremost in importance among the metallurgical problems mentioned by Mr. Swan still awaiting satisfactory solution stands the economical extraction of zinc from its ores. To realize the appalling wastefulness of the present methods of zinc smelting it is only necessary to bear in mind that in the very best practice from ¼ to 1 ton of coal are consumed in producing from 1½ to 2 tons of spelter from a 50 per cent. ore. Now, although, of course, the same amount of energy has to be expended in order to isolate 1 ton of zinc, whether it be chemically reduced or electrolytically deposited, yet the conditions under which the energy is extracted from coal and then utilized are so much more favorable in a good modern boiler, steam-engine and dynamo plant than in a zinc-smelting furnace, that the advantages would be all on the side of the electrolytic process, both as regards cost of production and purity of product, were only that process forthcoming. But unfortunately the econ-

* Spalding, "Hydraulic Cement." P. III.

omy of electrolytic zinc extraction processes is not so great as would at first appear. The reason of this is to be found in the fact that in the leach, previous to electrolyis, any silica which may be present in the ore is rendered gelatinous by the action of the acid, and it then holds a considerable quantity of zinc solution; consequently filter-presses must be used, and even then the extraction is only partial. The formation of this gelatinous silica may be overcome when treating ores which do not originally contain zinc silicate by roasting at a lower temperature, but in this case the zinc sulphide is only partially decomposed, and consequently is not acted on by the leaching medium. As often as the problem has baffled the skill of inventors, so sanguine are electro-chemists of its ultimate successful solution, which will probably be on the lines of an electrolytic leach, to which the above remarks do not apply; and, indeed, Brunner, Mond & Co. exhibit at Glasgow specimens of zinc of 99·96 per cent. purity, which Mr. Swan reports as having been made electrolytically on the lines suggested in the well-known Hoepfner patents."

FERRO-SILICON.

In his Presidential address before the Society of Chemical Industry, Mr. J. W. Swan refers to ferro-silicon as one of the newer class of alloys now being produced on a commercial scale by the electric furnace. At present the demand is small, and the production exceeds the requirements, but it is hoped that in time there may be a large demand for this alloy in connection with the manufacture of iron and steel. It has been proved that, where there is no excess of carbon, silicon improves some of the physical properties of steel, and that its thermal energy is of value in steel casting. Ferro-silicon is at present being manufactured at Meran, in the Austrian Tyrol, and at other carbide works in France.

Scrap iron, quartz, and coke are used as raw materials of the manufacture The daily yield of each furnace is 1,200 kilos. The product contains 77·5 per cent. Fe and 21·5 per cent. Si, and costs at Meran £8 per ton. The yield in the electric furnace is one ton per 5,000 k.w. hours.

X-RAY SLOT MACHINES.

The X-ray and the slot machine are modern utilities that have finally combined their energies to make a sidewalk show for the curious possessor of the nickel indispensable to operation. The apparatus includes a vertically mounted fluoroscope, which may be used when the tube is made active by dropping a nickel in the slot. The passer-by who desires to see the bones of his hand or wrist makes his contribution and places his hand in the proper position; the machine does the rest. With the exception of the fluoroscope, the necessary parts are enclosed, with suitable openings. The machine seems to be self-contained and is of a convenient height for use by a man of average stature. One of these curious machines has been placed in a Chicago restaurant, and it excites much attention from its novelty. The apparatus is built to afford pastime, principally, but it is also calculated to give the man-in-the-street a glimpse of natural phenomena that he might not otherwise obtain.—*Western Electrician.*

Section of Photography and Microscopy.

Stated Meeting held Thursday, November 7, 1901.

ON THE USE OF SENSITIVE PAPER IN X-RAY WORK

BY M. I. WILBERT.

The use of so-called "bromide papers" in X-ray work is, of course, not new or original. Roentgen himself, in his early publications on the subject of the X-rays, intimated that he had used sensitive photographic paper in the course of his investigations and experiments, and many if not all X-ray operators have from time to time made use of this variety of photographic material in their experimental work. The objections that most experimentors have had to contend with in the ordinary commercial brands of paper is the fact that the surface of even the so-called smooth paper is a decided matt. This matt surface gives the resulting picture the appearance of being buried in the texture or pores of the paper, with a consequent loss of much of the necessary detail. The finish or surface of this matt-surface paper is of such a nature that squeegeeing on glass or ferrotype plate does not materially improve the surface or appearance of the picture.

Of late years, several manufacturers have put upon the market a glossy variety of developing-paper as a substitute for, or to compete with, the well-known varieties of printing-out papers. This glossy variety of developing-paper has the advantage of keeping the image on the surface, and for this reason is well adapted for the reproduction of more detail in the picture.

It should be remembered that the developing-papers now on the market vary greatly in speed, or the amount of exposure that is necessary to produce the latent image, and it is obvious that the slow varieties now so extensively used, especially by amateurs, and in which the sensitive silver salt is composed largely, if not entirely of a chloride, are not

at all suited for X-ray work. We must confine ourselves therefore to the older and comparatively rapid bromide papers.

The particular paper that I myself have been most successful with is a comparatively new German brand of bromide paper now being introduced into this country. It is made by the "Neue Photographische Gesellschaft" in Berlin, Germany, and is marketed in different grades of smooth, glossy and rough; it is coated on what appears to be a very excellent quality of paper stock.

The glossy variety is one that is best adapted for X-ray work, on account of the smooth finish and fine texture of its surface. How well it is adapted to this particular purpose may be determined by an inspection of the samples shown here.

The question naturally arises, What possible advantages are to be derived from the use of sensitive paper instead of glass plates? The possible advantages are many, and it is my purpose now to call attention to some of the more evident points of vantage as they have occurred to us while experimenting with the various brands of bromide paper available at the present time.

First, the matter of price: in this the use of paper would result in a saving of from forty to sixty per cent. of the cost of dry plates. Other things being equal, this one feature alone would be of sufficient importance to insure the very wide use of a sensitive paper that could be relied on to give satisfactory results under all conditions and at all times.

Another advantage is the saving in possible breakage. Every X-ray operator has had experience in this line. The breaking of a glass plate usually occurs towards the end of an exposure, and always in a case that has necessitated a considerable amount of care in the preparing for and patience in making the exposure. The ominous click that accompanies the accident not only means the loss of a rather expensive plate, but also a waste of the time and energy that has been expended in preparing for and in making the exposure. Nothing of this kind is at all likely to

occur with paper, so that the exercise of ordinary precaution would insure us against any possible danger of wasted exposures.

The facility with which the resulting pictures may be stored will, of course, appeal to all, as the difference in bulk and weight is self-evident. One feature of considerable importance in this connection is the fact that the name of the patient and all the necessary data relating to the case or the making of the exposure may be written on the back of the exposed sheet before development, in this way obviating any possible chance of making a mistake by confusing two or more of the resulting pictures.

Many physicians who are not familiar with, nor in the habit of looking at photographic negatives, cannot see detail in a transparent plate, and, consequently, prefer to have a print. This opens up another possible field for sensitive paper. Not only would the use of this paper obviate the necessity of making positive prints, but we may, if we choose, utilize the paper in combination with glass plates for the same purpose. By exposing a piece of paper and a glass plate at the same time, and developing them in the same solutions, we not only make the paper print and the glass negative at the same time, but we also, in addition to this, have a more or less valuable means of control; for by comparing our results a possible flaw in the plate could not possibly be mistaken for a pathological condition of the part of the patient radiographed.

If for any reason we desire to have two or more prints of the same subject, we can readily obtain them by exposing the required number of sheets of paper at the same time. The paper itself offers little or no resistance to the rays, so that we can expose a dozen sheets as readily as we could one.

Probably the greatest advantage is the rapidity with which we can obtain the desired information. Those of you who have had any experience in this line well know how anxious the doctor usually is to see the result of the exposure; you also know that a plate in the process of development is not always the most reliable source of infor-

mation, so that, under ordinary circumstances, we are obliged to wait until the plate is sufficiently fixed to be transparent. This extra wait for the fixing bath can be avoided by using paper, as, after proper development and a thorough rinsing in water, the resulting picture may be examined in broad daylight without any appreciable damage by fog or other change of the residual silver salts. The necessary fixing in hypo may be done later.

These are but a few of the possible points of superiority that have presented themselves to us while experimenting, or in the regular routine use of the X-rays.

There are, of course, drawbacks and defects in paper at the present time. One of them is the comparative slowness of the emulsions used on ordinary bromide papers. This, to some extent, has been overcome by this same German company, in what they call their negative paper, the emulsion on which is much richer, and, consequently, more rapid than that used on their regular grades of paper. This negative paper is very thin, and is intended to replace celluloid films, and also the various kinds of stripping films that are at present being reintroduced and used quite extensively, especially in Germany. This thinness or transparency of the paper would also tend to do away with another rather serious objection to heavy bromide paper—the tendency for an image, especially of the heavier portions of the body, to veil over or fog; a perfectly transparent paper would give us all the possible advantages of a glass plate in this respect. There remains but one more serious question, and that is the keeping-quality of paper coated with a very sensitive emulsion of silver salts; and, while this may possibly be a serious, or rather a difficult problem, there appears to be no positive reason why manufacturers cannot obtain a paper that will not affect the sensitive salts in the emulsion.

In addition to its use as a substitute for glass plates in taking the impression direct, glossy bromide paper can, of course, be used to advantage for reproduction, or the making positive prints from X-ray negatives. For this purpose the German brand of paper also has some points of supe-

riority; for, in addition to its being a very rapid paper, so far as the time necessary for exposure is concerned, it has the added advantage of being a slow or rather steady developer, so that we have considerable latitude in this step of the process, and can modify the resulting picture to a considerable extent by either accelerating or retarding the same in the course of its development.

Those of you who are in touch with or consult German photographic or X-ray journals will probably recall the really beautiful reproductions on bromide paper that these journals occasionally contain. This so-called method of "light printing," while it appears to have originated in this country, does not seem to have been developed or followed to any considerable extent. In Germany, on the other hand, it has evidently been developed into a distinct branch of the printer's or, rather, the photographer's art. The printing and developing of these pictures is done automatically, by means of specially constructed machines, and it would appear that there was a possibility of developing this same method of photographic printing in this country so as to make it available for illustrating books and periodicals in cases where the presentation of detail is considered of sufficient importance to assume a possible slight increase in cost.

ELECTROCHEMICAL WORKS AT NIAGARA.

The *Electro-Chemist* gives the following interesting data:

The present total output of electricity at Niagara is about 50,000 H.P.; of this no less than 23,200 H.P. is consumed in electrolytic and electric smelting operations. This power is distributed as follows:

	H.P.
Electrical Lead Reduction Company	500
Acheson International Graphite Company	1,000
Pittsburgh Reduction Company	5,000
Carborundum Company	2,000
Matthieson Alkali Works	2,400
Niagara Electrochemical Company	500
Ampère Electrochemical Company	300
Union Carbide Company	10,000
Oldbury Electrochemical Company	1,000
Roberts Chemical Company	500
Total	23,200

Cassier's Magazine for May gives some interesting statistics in connection with these works.

The Electrical Lead Reduction Company reduce lead from its sulphide in the form of sponge, principally for the manufacture of litharge. The original alternating current at 2,200 volts is used for induction motors, which in turn drive direct-current dynamos which generate current at 100 volts. (See *Electro-Chemist and Metallurgist*, i. p. 32.)

The Acheson International Graphite Company convert anthracite into graphite in the electric furnace. The current is used at 80 volts pressure. (See *Electro-Chemist and Metallurgist*, i. p. 89.)

The Pittsburgh Reduction Company, it is needless to say, extract aluminium from baeuxite by the Hall process. (See *Electro-Chemist and Metallurgist*, i. pp. 2, 10.) The two-phase alternating current, which enters the works at 2,200 volts, is converted first to 130 volts and then by rotary converters, each of 600 kilowatt capacity, to direct current at 160 volts.

The Carborundum Company produce silicon carbide in 110-volt alternating-current electric furnaces.

The Matthieson Alkali Works transfer the 2,200 volts two-phase current into direct current at 230 volts. They produce chloride of lime and caustic soda by the Castner process.

The Niagara Electrochemical Company convert their current into direct at 165 volts for the production of sodium and sodium peroxide from caustic soda.

The Union Carbide Company work their electric furnaces (200 H.P. each) at 110 volts and 25 alternations. According to *Cassier*, this company probably uses more electric power than any other one factory in the world.

The Roberts Chemical Company use direct current at low voltage for the production of caustic potash, etc.

GLASS COLORING BY PENETRATION.

M. Léon Lémal proposes to color glass, not throughout the mass nor in enamel fashion, but by what he calls penetration. A little silver salt is put on the surface of the glass, which is then heated to 500° or 550° C. The excess of salt having been removed, the surface appears yellow, the color penetrating to a depth of 0·17 millimeters when the baking has lasted for about five minutes. After an hour, a layer of double that thickness would be colored; after eighteen hours the color would have penetrated through a glass plate 1·6 millimetres in thickness. In reflected light this yellow displays a beautiful greenish or blueish fluorescence. The intensity of the coloration depends, of course upon the quantity of salt applied. But very minute quantities suffice. To transfer a lace pattern on glass, it is only necessary to dip the lace in a 0·001 solution of silver nitrate and then into potassium sulphide. According to *La Nature*, colored monograms can easily be obtained in this way, and what is still more interesting, ordinary collodion negatives can be printed on glass in various colors. Silver and copper give a red; gold and iron salts have also been used. When the baking is continued for a long period, the coloring matter is renewed from time to time, say every six hours. The observation has a scientific interest as well. The rate of penetration would probably depend upon the nature of the glass, and upon the atomic volume of the metal. W.

SHIMER'S COMBUSTION APPARATUS.

[*Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the invention of P. W. Shimer, Easton, Pa. Sub-Committee: Dr. H. F. Keller, Chairman; Dr. Jos. W. Richards, G. H. Clamer.*]

HALL OF THE FRANKLIN INSTITUTE,
[No. 2179.] PHILADELPHIA, June 5, 1901.

The Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating the merits of Shimer's Combustion Apparatus, reports as follows:

Among the more difficult and time-consuming routine work of analytical laboratories, particularly in iron and steel works, is the determination of carbon by the combustion method.

This method consists in strongly heating in a current of pure oxygen a weighed quantity of substance containing the carbon, or the latter after it has been separated from the substance, and collecting the resulting carbon dioxide in caustic alkali. The percentage of carbon is then calculated from the increase in weight of the alkali.

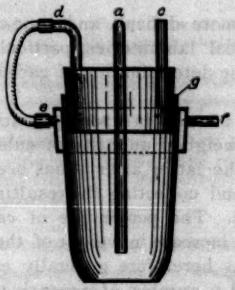
The apparatus heretofore generally employed for this purpose included a number of expensive and bulky parts, such as a combustion furnace, tubes of platinum, porcelain, or hard glass, and a supply of oxygen gas. The use of this apparatus is extremely wasteful, inasmuch as the quantity of fuel consumed in the furnace, and the heat generated in it, are out of all proportion to the small amount of carbon to be oxidized, and, in spite of this great waste, the complete combustion of graphite presents considerable difficulties where the pressure of the gas supply is small.

In the invention before your committee, the cumbersome furnace is replaced by a blast lamp and Bunsen burner; a crucible of special construction takes the place of the combustion tube, and air is substituted for the oxygen.

The essential and novel part of the apparatus consists in a platinum crucible, the upper part of which is water-jacketed, and a water-cooled stopper made of copper, provided with inlet and outlet tubes for the air.

Internally the crucible has the same shape and dimensions as the crucibles commonly used for fusions; the cooling chamber is on the outside, it is $\frac{1}{4}$ of an inch wide and $\frac{1}{8}$ of an inch deep, and has short inlet and outlet tubes, *e* and *f*, placed horizontally and on opposite sides. The whole is made of platinum and in a single piece.

The hollow stopper is made of sheet copper, and perforated to give passage to the copper tube, *a*, which serves as inlet for the air in the crucible, and provided also with



inlet and outlet tubes, *c* and *d*, for the cooling water. All the joints in this stopper are carefully brazed (see illustration). The flare of the sides of the stopper conforms closely to that of the crucible walls, but the stopper is made somewhat smaller than the crucible opening, in order to allow space for a small rubber band which serves to make an air-tight joint between stopper and crucible. The cooling chambers of the crucible and stopper are connected by a rubber tube, so that the same water may pass through both.

The rubber band is thus, on both sides, in contact with water-cooled metallic surfaces, and there is no risk of its

burning or softening when the lower part of the crucible comes to a bright red-heat in the course of a combustion.

The trains for purifying the air and absorbing the products of combustion are identical with those formerly used.

The advantages gained by Shimer's construction of the combustion chamber are as follows:

(1) The replacement of a bulky and complicated apparatus by one of compact and simple construction.

(2) A considerable saving in the cost of the apparatus and repairs.

(3) A very great economy in the gas used for heating.

(4) The possibility of effecting a rapid and complete combustion of graphite and carbon in difficultly soluble alloys in laboratories where gas is supplied at a low pressure.

(5) The use of the crucible for the determination of combined water and carbonic acid in minerals, ores, cements, etc.

After having carefully examined and tested the apparatus, your sub-committee is satisfied that its construction embodies novel and valuable features, and that it must be regarded as a greatly improved form of one of the most important laboratory appliances. The judgment of your sub committee is corroborated by the facts that the invention, although patented less than a year ago, has already found its way into most of the laboratories of the iron and steel works of this country, and that a large number of unsolicited testimonials from the heads of those laboratories agree that it effects economy in time, labor and expense.

In view of the ingenuity displayed in the construction of this device, and its great practical value, your sub-committee respectfully recommends the award of the John Scott Legacy Medal and Premium to the inventor by the Franklin Institute, through its Committee on Science and the Arts.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, October 2, 1901.

Attest: WM. H. WAHL, *Secretary.*

BOOK NOTICES.

Theoretical Elements of Electrical Engineering. By Charles Proteus Steinmetz. 8vo, pp. vii + 327. New York: Electrical World and Engineer, Inc., N. D. (Price, $2.50.)

This work is divided into two parts. Part I treats, under eighteen heads, the fundamentals of direct and alternating currents, with one or more examples under each head elucidating the theory.

Part II comprises a series of monographs descriptive of the more important electrical apparatus, alternating as well as direct current. These are treated under four divisions: (*a*) Synchronous Machines; (*b*) Commutating Machines; (*c*) Synchronous Converters; (*d*) Induction Machines. W.

Electrical Designs, comprising instructions for constructing small motors, testing instruments and other apparatus, with working drawings for each design. Reprinted from the *American Electrician*. 8vo, pp. viii + 262. New York: American Electrician Company, 1901. (Price, $2.00.)

This work is a reprint of a series of articles giving details of the construction of a great variety of electrical apparatus and machinery, most of which have been actually built and operated.

They embrace specifications and working drawings of a number of motors and generators of various types, transformers, rheostats, meters, galvanometers, testing sets, photometers, lamps, induction coils, batteries, etc. The writers of these articles are all well known. W.

Franklin Institute.

[*Proceedings of the stated meeting held Wednesday, November 20, 1901.*]

HALL OF THE INSTITUTE,
PHILADELPHIA, November 20, 1901.

President JOHN BIRKINBINE in the chair.

Present, 180 members and visitors.

Additions to membership since last month, 30.

The President in a brief address referred to the recent occurrence, in this city and vicinity, of an abnormal number of disasters destructive of life and property (see appendix), and suggested that the subject be referred to a special committee to consider whether some action could not properly be taken by the Institute that would reduce the hazard to life and property traceable to our industrial growth and methods of transportation.

Dr. Samuel W. Stratton, director of the newly established National Bureau of Standards, read an interesting paper on the organization and work of the bureau. (Paper and discussion thereon will appear in the JOURNAL.)

Mr. Martin I. Wilbert described his experience with the use of Sensitive paper in X-ray work, and exhibited numerous specimens of his work. (Referred for publication.)

Mr. F. E. Ives made a communication on "The Half-tone Trichromatic Process," and illustrated the subject by means of his specially devised camera and with specimen prints. (Referred for publication.)

Under new business, Prof. Lewis M. Haupt called attention to the bill of Senator Frye presently to be considered by the Congress of the United States, to create a new Department of Commerce and Industries. He urged the propriety of an endorsement of this measure in general, but proposed that the Institute should suggest that the bill be amended so as to permit of river, harbor and other improvements being made by the citizens of localities affected thereby, at their own cost, when no public money was available for the purpose.

Professor Haupt offered the following preamble and resolutions in support of his argument, viz.:—

RESOLUTIONS TO PROMOTE COMMERCE.

Whereas, Greater and cheaper transportation facilities are essential to the development of our domestic and foreign commerce;

Whereas, The limited biennial appropriations are wholly inadequate to meet the requirements of the country, being only about eight per cent. of the approved projects;

Whereas, The former policy of authorizing the improvement of our waterways by private capital resulted in a rapid development without cost or risk to the general Government;

Whereas, Early and economical results may be secured by a partial return to this method in localities where no provision has been made for immediate improvement;

Whereas, It is proposed to create a Department of Commerce to exercise general jurisdiction over transportation on land and water; therefore, be it

RESOLVED, That said Department of Commerce should be empowered to authorize the improvement, by individuals or by corporations, of such rivers, harbors, canals or other waterways as are not provided for under the River and Harbor or the Sundry Civil Bills, and upon plans and regulations to be approved by the said Department; *Provided*, that no part of the funds for such works shall be drawn from the public treasury of the United States.

RESOLVED, That the establishment of a Department of Commerce and Industries is approved and its early inauguration recommended.

On motion of Mr. Thos. P. Conard, numerously seconded, the subject, with preamble and resolutions, was referred to a special committee of five, to be named by the President, with instructions to report at the next stated meeting of the Institute.

On Dr. Geo. F. Stradling's motion it was resolved that a special committee be appointed by the President, to consist of one member from each of the Sections and three from the membership-at-large, to consider the advisability and feasibility of the adoption of the metric system in the United States.

Mr. A. E. Outerbridge, Jr., referring to the introductory remarks of the

President bearing on the increasing hazards to life and property, associated with the expansion of our manufactures and transportation methods, moved that a special committee be appointed, in conformity with the President's suggestion, to consider and report upon the subject at a future meeting. Carried.

After some discussion of Dr. Stratton's paper, the meeting adjourned.

WM. H. WAHL,
Secretary.

APPENDIX.

REMARKS OF MR. JOHN BIRKINBINE MADE TO THE MEMBERS OF THE FRANKLIN INSTITUTE.

The Franklin Institute, with a membership distributed over the United States, and having many foreign members, does not ordinarily take cognizance of local matters, although the Institute was originally a local organization and its membership has broadened because the value of its work was recognized. However, a large propotion of the active members are resident in or near the city of Philadelphia. Even if this were not the case, consideration of some affairs affecting this locality can properly come before it, particularly as these have a widespread application and command general interest.

Within a few months a number of abnormally serious disasters, some resulting in great sacrifice of life, have been chronicled in this immediate vicinity—disasters of such moment as to invite attention much beyond the immediate locality of Philadelphia. An explosion destroying several houses on Locust street; the wreck of the steamboat "City of Trenton" by a boiler explosion; the destruction of a business house on Market street in the heart of the city where, in mid-day, the lives of more than a score of persons were sacrificed, are very late instances. Others could be mentioned, such as explosions due to chemicals and gasolene in various parts of the city, and the falling of a business building in the centre of the city owing to work about its foundations—surely, sufficient to suggest an inquiry as to why such disasters should occur in or about a great city which is renowned for the technical knowledge and practical experience of many of its citizens. Here are colleges; institutions like the Franklin Institute; preparatory and trade schools; many and varied industries; armies of skilled artisans and mechanics; numerous technical specialists; also Government, State and Municipal officers clothed with authority under statutes to inspect and, if necessary, condemn doubtful structures or apparatus, and yet, within a very brief interval a series of terrible disasters, replete with sickening details, have resulted in horrible sacrifices of life and great loss of property.

Such occurrences have not been restricted to this locality, but other portions of the conntry have contributed their quota, and most of the large cities and some of the smaller ones could add to the record of accidents (often misnamed) in mine, shop or factory, which would make a story of disasters appalling in its array of loss and danger.

The great majority of these can be credited to one of four causes:

First. The laws are insufficient to secure the required protection to life and property.

Second. Such laws as exist are not enforced, or enforced with such laxity as to be equally dangerous.

Third. Lamentable ignorance or gross carelessness on the part of those who design, construct or operate plants or industries.

Fourth. Public indifference, due to familiarity with existing dangers, until local disasters cause spasmodic awakenings, followed too quickly by normal conditions.

Your attention was invited to one phase of danger by the address of Mr. McDevitt two months ago, and the Engineering Section has under discussion boiler design, having given particular attention to the wreck of the "City of Trenton," and an expert jury is, under the coroner's direction, now discussing the subject of fireproof buildings and fire escapes. But we should not stop at this. The Institute many years ago prepared a report on boiler explosions which is to-day considered an authoritative expression. The Engineering Section may supplement this by the result of its inquiry.

It would seem that the time is ripe for a general discussion upon reducing hazards to life and property traceable to our industrial development and transportation methods.

It is not presumed that such discussion is to fix responsibility for disasters, for this is a grave matter which it is not the function of the Institute to locate; but we may be able to trace the causes with the expectation of suggesting remedial measures by a full and fair discussion of the deficiencies in existing laws, and possibly indicate failures to enforce protective measures which have been provided. We certainly could arouse public sentiment and probably be the means of instructing some upon details which have been imperfectly recognized. Such an investigation is in line with the work of the Franklin Institute and in keeping with its functions. It will probably result in a committee making a report to the Institute which, if adopted, will carry the weight which has always been accepted as representing the honored name of our organization. It is recommended that a committee, upon which there shall be a representative of the Committee on Meetings and of each of the Sections to which details of the investigation would fall, in addition to members selected from the Institute-at-large, be formed to consider the hazards to human life and property traceable to our industrial development and transportation methods.

SECTIONS.

(*Abstracts of Proceedings.*)

PHYSICAL SECTION.—*Stated Meeting*, September 25th, 8 P.M. Dr. Geo. F. Stradling in the chair.

Mr. Wm. McClellan, of the University of Pennsylvania, presented a communication entitled, "A Review of Recent Progress in Heat." Discussed by Messrs. Stradling, Richards, Goldschmidt, and Pawling.

JESSE PAWLING, JR.,
Secretary.

CHEMICAL SECTION.—Proceedings of the *Stated Meeting*, held Thursday, October 24th, 8 P.M. Dr. W. J. Williams in the chair. Present, 18 members and visitors. The evening was devoted to the subject of "Explosions at Fires, with Suggestions as to Their Orgin," by Wm. McDevitt, Inspector to the Philadelphia Board of Fire Underwriters.

The speaker gave a number of experimental demonstrations of the explosibility of the chlorates, nitrates, and analogous mineral compounds, and of various organic products.

Discussed by Messrs. H. W. Jayne, H. F. Keller, C. A. Hexamer and others. In connection with the subject, Dr. Jayne mentioned the explosion of an empty glycerin drum by heatng.

W. E. RIDENOUR,
Secretary.

SECTION OF PHOTOGRAPHY AND MICROSCOPY.—Proceedings of the *Stated Meeting*, held Thursday, November 7, 1901, at 8 P.M. Dr. Chas. F. Himes in the chair. Present, 21 members and visitors.

The Special Committee on Photographic Record Work reported a revision of its classification of subjects proposed by Mr. J. W. Ridpath. The revised classification was approved.

The question of the size of plate to be adopted as standard was considered. Mr. J. E. Ives called attention to the fact that the 5 x 7-inch plate was the largest in general use by amateurs, and thought it would be advisable that the 6½ x 8½-inch plate specified in the report be changed accordingly. On Dr. Leffmann's motion, numerously seconded, this change was unanimously approved.

The committee's report, with the above amendment, was then adopted. (The report, as adopted, is hereto appended).

Specimens of albums made to embody the committee's views, were shown by Mr. Ridpath, and were freely criticized by the members.

The chairman presented for the album several prints of historical scientific apparatus, to wit: Dr. Priestley's original burning glass, with which he had made the discovery of oxygen; Priestly's air-gun, and other interesting subjects. He called attention to the desirability of having the descriptive matter appended to such records as full, though concise, as possible.

On Dr. Leffmann's motion, the Special Committee was instructed to proceed with the preparation of a record album, which should embody the suggestions brought out in the discussion of the subject.

Mr. Martin J. Wilbert followed with a paper on "The Use of Sensitive Paper in X-ray Work," which was illustrated with the aid of a large number of prints made in connection with the work of the German Hospital.

Dr. Henry Leffmann exhibited and described a series of lantern slides relating to modern methods of paper manufacture.

The same speaker called attention to the fact that the next meeting of the Section would be devoted to the subject of "Overexposure and Reversal in Photography," with especial reference to the investigations of Professor Nipher, of St. Louis.

By invitation, Mr. Wanner gave an account of some experiments that he had made in this direction.

Mr. Ives exhibited and described for Mr. Samuel Sartain a number of celluloid transparencies.

WM. H. WAHL,
Secretary pro tem.

APPENDIX.

[*Report of the Special Committee on Photographic Record Work.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, October 1, 1901.

To the Section of Photography and Microscopy:

The Comittee on Record Work, appointed in accordance with the resolution adopted at the stated meeting of the Section in May last, respectfully reports that it has held several meetings, and decided to recommend the following plans:

While photographs of any convenient size will be accepted if satisfactory, it is recommended that the 5 x 7-inch plate be chosen whenever possible.

As it is expected that albums will be provided by the Institute, prints should be sent in unmounted and properly trimmed. Except in special cases duplicates are not to be sent.

It is proposed that a supervising committee, chosen in some way that will secure the full representation of the Section, shall have charge of the acceptance of pictures and their arrangement in the albums or elsewhere.

Pictures become the property of the Institute, unless specific arrangements otherwise are made.

The committee offers the following classification of subjects, suggesting that the arrangement iu the albums or elsewhere shall conform to the system.

CLASSIFICATION.

(1) Machines, implements and scientific apparatus, especially those passing out of use; including manipulations in manufactures and trades.

(2) Transportation by land and water, ancient and modern.

(3) Buildings, bridges, and other useful structures, illustrating methods of erection.

(4) Buildings of historic interest, particularly scientific institutions, to include important ancient landmarks liable to be torn down.

(5) Portraits of distinguished men who have made important contributions to the sciences and mechanic arts.

(6) Documents of historic or public interest, including those of a scientific character.

(7) Catastrophies and incidents of public interest.

The committee has considered the question of albums, and submits various samples for the examination of members.

HENRY LEFFMANN,
U. C. WANNER,
J. W. RIDPATH,
Committee.

MINING AND METALLURICAL SECTION.—Proceedings of the *Stated Meeting* held Wednesday, November 13th, Prof. F. L. Garrison in the chair. Present, 32 members and visitors.

After the transaction of the usual formal business, Dr. J. A. Matthews, of Columbia University, New York, read a paper on "The Constitution of Metals and Binary Alloys." The communication was profusely illustrated with stereopticon views, and was discussed by Messrs. Paul Kreuzpointner, Robert Job, W. R. Webster, A. E. Outerbridge, Jr., James Christie, and the author.

Paper and discussion are reserved for publication in full.

G. H. CLAMER,
Secretary.

MECHANICAL AND ENGINEERING SECTION.—*Stated Meeting* held Thursday, November 14th, 8 P.M. Mr. James Christie in the chair. Present, 45 members and visitors.

The subject for discussion was "Steam Boiler Inspection, with Especial reference to Design, Construction and Service."

The discussion was opened by Mr. Geo. B. Hartley, and was participated in by Messrs. John M. Hartman, R. D. Kinney, Jos. C. Steinmetz, James Christie, and others.

The discussion will be printed as a supplement to the subject of the discussion held at the stated meeting October 10th.

DANIEL EPPELSHEIMER, JR.,
Secretary.

ELECTRICAL SECTION.—Stated meeting. Thursday, November 21st. Mr. Thomas Spencer in the chair. Present, 52 members and visitors.

Dr. A. E. Kennelly, in his remarks on the Electrical Arts at the Pan-American Exposition, took up the subject of high-tension switches, and gave an historical sketch of the development of the switch from its earliest form, in which a simple wire was laid across two terminals, to the special devices in use to-day which control currents equivalent to capacities of 5000 horse-power. He spoke successively of the bell switch, the earliest types of knife switches and automatic circuit breakers, and the oil switches, and special high potential switches which are now being used, all of which showed the great amount of ingenuity which had been displayed in their design and manufacture.

Regarding the Edison storage cell, he stated that no tests had lately been made as to its efficiency, but exhibited several plates which are used in this type of cell.

Mr. C. J. Reed spoke on polarization in batteries, and called attention to the numerous different definitions which had been given to this term; each definition was correct if taken from the point of view of the definer; but none of them seemed to really take in the actual effects or results which took place in the batteries. Mr. Reed thought that the proper definition of polarization was a progressive electro-chemical exhaustion of the electro-chemical reagents.

Paper was discussed at some length and discussions proved of considerable interest.

RICHARD L. BINDER,
Secretary.